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ABSTRACT

This packet contains 88 lesson plans for a laboratory course in farm and ranch mechanical repair. The lesson plans are organized into six units covering the following topics: occupational information, construction and maintenance (safety, farm carpentry, farm water supply and sanitation, farm electricity, concrete), hot metal work (oxyacetylene welding and cutting, arc welding, soldering), farm power and machinery maintenance and repair (small gasoline engines, farm trucks and tractors functions and maintenance, farm machinery and equipment), fence building and repair (planning, building and maintaining fences), and agricultural leadership (Future Farmers of America, Parliamentary Procedure). Each lesson plan contains a topic, suggested procedures and activities, information for the teacher to use in presenting the lesson, worksheets for students, transparency masters with accompanying scripts, and references. Materials are illustrated with line drawings, and an outline of the course is provided. (KC)

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COURSE OUTLINE FOR LESSON PLANS FOR PRE-EMPLOYMENT LABORATORY TRAINING IN CVAE - VEH FARM AND RANCH MECHANICAL REPAIR

I. Occupational Information

A. Opportunities in Agricultural Mechanics Occupations
   1. Employment Opportunities and Occupational Requirements
   2. Choosing an Occupation
   3. Finding a Job and Preparing for an Interview
   4. Employee-Employee and Employee-Employer Relations
   5. Employee Benefits and Payroll Information

II. Construction and Maintenance

A. Introduction
   1. Shop Rules and Regulations
   2. Shop Safety and Clean-Up
   3. Identification and Use of Hand Tools
   4. Identification and Use of Power Tools
   5. Identification and Use of Fasteners
   6. Identification and Use of Building Materials
   7. Identification and Use of Farm Level

B. Farm Carpentry
   1. Planning and Constructing Buildings and Equipment
   2. Reading Building Plans and Blueprints
   3. Computation of a Bill of Materials
   4. Building Layout
   5. Roof Designs and Roofing Materials
   6. Marking and Cutting Common Rafters
   7. Selecting and Applying Paint

C. Farm Water Supply and Sanitation
   1. Skills Needed to Install Pipe and Plumbing Fixtures
   2. Skills Needed to Maintain Farm and Home Water System

D. Farm Electricity
   1. Electrical Safety and Terms
   2. Electrical Wiring
   3. Types and Uses of Electric Motors
   4. Care and Maintenance of Electric Motors

E. Concrete
   1. Estimating the Amount of Concrete Needed

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2. Construction of Forms and Reinforcing
3. Placing, Finishing, and Curing Concrete
4. Concrete Masonry

III. Hot Metal Work

A. Oxyacetylene Welding and Cutting
1. Introduction
2. Safety Precautions
3. Procedure For Assembly of the Oxyacetylene Rig
4. Procedure For Turning the Rig On and Off
5. Cutting Metals
6. Welding and Brazing Metals

B. Arc Welding
1. Introduction
2. Types of Welders
3. Safety Precautions
4. Fundamentals of Welding
5. Electrodes
6. Basic Steps in Welding
7. Welding Joints
8. Out-of-Position Welding
9. Other Uses of the Arc Welder

C. Soldering

IV. Farm Power and Machinery Maintenance and Repair

A. Small Gasoline Engines
1. Basic Principles of the Four-Cycle and Two-Cycle Internal Combustion Engine
2. Trouble Shooting
3. Disassembly and Reassembly of the Small Gasoline Engine
4. Checking and Adjusting the Carburetor and Governor
5. Checking and Adjusting Valves
6. Checking and Adjusting the Electrical System
7. Inspecting and Repairing the Cylinder and Piston
8. Inspecting and Servicing the Engine Lubrication System

B. Farm Truck and Tractor Maintenance
1. Operation and Safety
2. Daily Care
3. Servicing Air Cleaner Assembly
4. Lubrication

C. Function and Maintenance of Farm Truck and Tractor Systems
   1. Cooling
   2. Fuel
   3. Ignition
   4. Lubrication
   5. Power Train
   6. Braking
   7. Hydraulics
   8. Steering
   9. Tires

D. Farm Machinery and Equipment
   1. Types
   2. Inspection
   3. Adjustment
   4. Reconditioning

V. Fence Building and Repair

A. Planning Fences
   1. Fencing Materials
   2. Types of Fences
   3. Wire Gauges and Types

B. Building Fences
   1. Common Fence Failures
   2. Spacing of Posts
   3. Bracing and Setting Posts
   4. Stretching Wire
   5. Fastening Wire
   6. Splicing Wire

C. Maintaining Fences

VI. Agricultural Leadership

A. The Future Farmers of America
B. Parliamentary Procedure

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for
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in
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OCCUPATIONAL INFORMATION

Unit A: Opportunities in Agricultural Mechanics Occupations

Topic 1: Employment Opportunities and Occupational Requirements

Suggested Procedure and Activities: A survey during the class discussion of the number and type of local farm and ranch mechanical repair jobs may be of interest to the entire class.

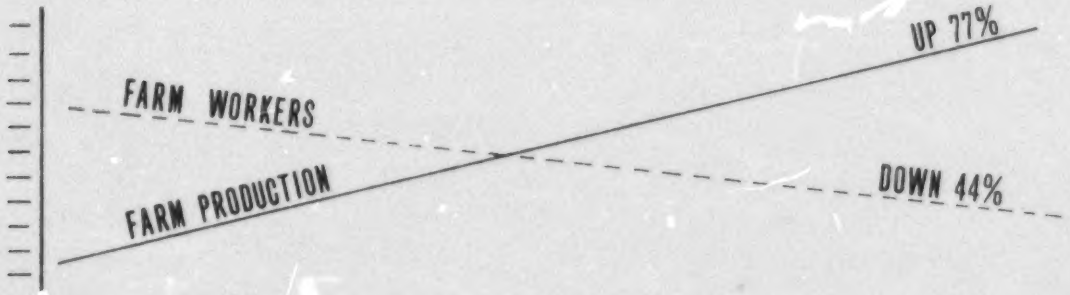
1. Farm and Ranch Mechanization

Many changes have been experienced in the agricultural industry due to mechanization. The increase in food production during the last half century has been due to mechanization. An example of advanced mechanization would be the 1901 gasoline tractor. It weighed 20,000 pounds and developed 22 drawbar horsepower. A modern tractor that develops 22 horsepower weighs only 3,000 pounds.

Some of the major changes in the agricultural industry are:

a. During the early 1900's one farmer produced enough food and fiber for himself and six other people. Today one farmer produces enough food and fiber for himself and approximately sixty other people.

b. Farm workers have decreased in number, yet farm production has increased.



c. Farms are increasing in size, but the number of farms is decreasing in most states. 40 percent of the farms produce 87 percent of the food and fiber sold from U. S. farms.

d. The U. S. has lost three million farmers in the last 25 years. Farm population has dropped from 8.6 percent of the total U. S. population in 1960, to less than 4 percent today.

e. Today's farmers and ranchers have better educational opportunities, more time for recreation, more home conveniences, and better facilities and equipment than ever before.

f. Farm business is considered big business. Agriculture is one of the largest industries in the United States.

A good farm and ranch maintenance employee will continue to be in demand as the agricultural industry grows and changes. This type of employee should possess an aptitude for: constructing and maintaining fences; constructing and maintaining farm buildings; welding; and repair and maintenance of small gasoline engines, tractors and equipment.

2. Occupational Requirements

In order for an employee to succeed in the world of work, several survival skills are necessary. Among these skills or abilities are the following:

a. Have basic reading, writing, speaking, and arithmetic skills.

b. Capable of managing time and materials.

c. Capable of using initiative and imagination in making independent decisions.

d. Ability to follow instructions in a safe manner.

e. Ability to work as a team member, with or without supervision, and sometimes under tension or pressure.

f. Ability to adjust to various work situations.

g. Have specialized training and ability to use job materials, machines, or tools.

h. Ability to work with people and seek information or assistance.

i. Know and accept own abilities, strengths, and weaknesses.

j. Maintain good health and appearance.

k. Understand what is expected; be dependable, punctual, and give an honest day's work.

1. Possess loyalty to the employer and pride in work done.

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OCCUPATIONAL INFORMATION

Unit A: Opportunities in Agricultural Mechanics

Topic 2: Choosing an Occupation

Suggested Procedures and Activities:

The teacher may wish to make copies of the personal inventory and occupational requirements forms and make them available to students. These appear at the end of the technical information.

1. Importance of Choosing a Career

The occupation in which one is employed is the central activity around which Americans plan their lives. In addition to determining a person's way of life it influences choice of friends and the way in which leisure time is spent. It is also the major factor in a person's identity.

The average individual works in an occupation about 2,000 hours a year, or about 80,000 hours in a lifetime. These figures are based on a 40-hour week, 50 weeks a year for a period of 40 years. Most people begin working in an occupation in their early twenties and retire at the age of 65.

Since work has such a great influence upon the individual, selecting an occupation is one of the most important considerations in the life of a young adult. All young people should involve themselves in experiences which will prepare them for successful employment and will challenge them according to their aptitudes, interests, and personality.

2. Why People Work

Most people work because of (1) economic benefits, (2) social benefits, or (3) self fulfillment. A discussion of these and other reasons follows:

Livelihood - People work to provide their families with the basic essentials of life--food, clothing, and shelter. Once these needs are met, other needs become important.

Human Relationships - Employment provides companionship and association with other people. Most people seek companionship and prefer to work with others having similar interests. Being part of a group provides a feeling of belonging.

Personal Development - A job provides the opportunity for further self development and is a means of attaining goals by developing new skills and acquiring more

knowledge. It allows one to reach the fullest potential.

Service - This is defined as tasks performed for the benefit or use of others. There is satisfaction in the production of quality products or the providing of a useful service. A person likes to feel that the work performed is of value to others and a contribution is being made to the general welfare of the community and country.

Security - An occupation or job is a form of security. Full-time employment and a regular income provide satisfaction and stability by eliminating the worries of an insecure future. Not all the "security aspects of a career" are in the form of wages or salaries. Fringe benefits such as insurance policies, retirement benefits, and vacation must also be considered. Various occupational choices may provide different forms of security to the worker.

Success - Ambitious people are interested in securing employment which offers an opportunity for advancement. Employers are interested in applicants who like a challenge and want to be successful in life. Employment provides a means of being successful.

3. Consequences of Choosing an Occupation

Each individual is "one of a kind" and has unique abilities, aptitudes, interests, and characteristics. Some people have strong emotional needs and may give very little thought to the financial returns from an occupation if these needs are met. Others may desire intellectual stimulation, while still others may desire the prestige of working with influential people, or employment in an upper level position. Some people desire to be a leader, exert power, or gain fame. Regardless of a person's needs and desires, the individual must realize that the occupational choice will have considerable influence on his/her life.

Some of the consequences of occupational choice are given below:

Transparency No. 1

1. The occupational choice may determine whether a person is employed, underemployed, or unemployed. Some occupations offer limited or part-time employment. Competition for jobs in some occupations is keen. If possible, the occupational choice should be one that is known to be relatively stable.

2. Occupational choice may determine a person's associates. Companionship and friendship are two of an individual's most basic needs. Nearly all people find it essential to visit with others who have similar interest. An occupation will provide more satisfaction if a person can "identify" with fellow employees in both work and leisure activities.

3. Occupational choice may determine success or failure. Many factors such

as ability, effort, and luck affect success, but of primary importance is the ability to perform the assigned tasks. People differ in both the nature and level of their abilities. Occupations differ in abilities required and performance levels. By choosing an occupation that will utilize strengths and make minimum demands of weaknesses, a person can increase chances of success.

4. Occupational choice may determine whether one likes or dislikes his work. In order to have job satisfaction, a worker must like to perform most of the tasks associated with the job. To some extent, individual interests and abilities will influence whether a person likes or dislikes his job. Most occupations have duties which are not enjoyable. A person should recognize that not all duties will be enjoyable, regardless of the occupation.

5. The occupational choice may determine one's contribution to society. Most occupations contribute directly or indirectly to the welfare of society. However, the occupational choice will determine the extent of the contribution and other peoples' opinion of the contribution.

6. Other aspects of life that may be influenced by occupational choice are area in which a worker lives, choice of friends, marriage partner, school children will attend, physical and mental health, salary, and visits to other members of family.

4. <u>High School is the Crossroads</u>

Much has been written and considerable effort has been expended in the United States to keep high school students from dropping out of school. Many thousands of the "dropouts", as they are called, have the erroneous assumption that quitting school and getting a job will solve many of their problems. In reality, this is just the beginning of their problems because most dropouts are destined to become common or semi-skilled laborers. Jobs as laborers do not offer the opportunities for advancement, gaining more knowledge, or improving and increasing skills. Many "dropouts" have the ability to graduate from high school. Occupational knowledge and skills can be acquired while attending high school.

Technology is advancing at a very rapid rate, and it is expected that it will continue to advance. Many occupations require employees to continually upgrade their skills. To take advantage of employment in these occupations, the worker must have an educational background for the development of new skills. This is in contrast to a few years ago when a high school education was not important because employment was based more on physical strength rather than "brains." In the future there will be little opportunity in the labor market for the uneducated or the unskilled.

The decisions made by high school students will affect many of them for the rest

of their lives. Some of the decisions that they must make at this time are as follows:

1. Whether to continue education in an area vocational-technical school, a community college, or a four-year college.
2. Should job be sought after completing high school?

While there is still time to plan for the future, consideration should be given to these questions. Any decision made at this time will involve a certain amount of risk; however, this should not be thought of as a final decision. Decisions should be based on their expected outcome. A decision based on facts and sound thinking will probably be a good decision. Study and time are required in the making of decisions. In the final analysis, each person must make the decision as to his/her status in life and must be prepared to adjust to the circumstances or outcomes of these decisions.

5. Personal Qualities and the World of Work

A student should recognize that individuals differ in abilities, talents, interests, attitudes, and ambitions and have different strengths and weaknesses. All people are not capable of doing the same thing, nor do all people want to do the same thing. Interests, abilities, and other characteristics, however, can be changed through the acquisition of knowledge and development of skills.

Career choices should be built around strengths, interests, and abilities. An attempt should be made to overcome weaknesses. If this is not possible, a career should be planned in which weaknesses will not hinder the occupational choice.

In order to make a realistic occupational choice, it is necessary for most students to conduct a self analysis. The purpose of the analysis is to determine what students really are, not what they think they are. Parents, teachers, friends, and guidance counselors are well-meaning and possess considerable knowledge and experience. The final decision, however, should be the student's. Serious consideration should be given to the following personal qualities when making the self appraisal.

Transparency No. 2

Ability - This refers to the capacity to perform. When it is said that a person has the ability to do something, it means that this person is skillful at performing the task. The ability may have been acquired through training and hard work, or because of a natural talent. Grades are an indication of the ability to perform in a certain subject matter area. Some students seem to have greater abilities in all subject matter areas, while others may be weak in one or more areas. Perhaps the class members have already recognized that they perform better in certain areas.

A self appraisal should reveal a true picture of the student's strengths and weaknesses. The school guidance counselor and teachers are familiar with tests that measure ability and achievement.

Talents - A person possessing the ability to perform certain tasks without training is said to have an aptitude or talent for these things. For example, the class may know of someone who learned to play a musical instrument with little or no instructions, while others develop a limited ability after years of study and instruction.

Talent may be defined as something a person does well. Those possessing special talents are fortunate. It is common for people to choose an occupation on the basis of their talents. If the self appraisal reveals that a student has a special talent, how this talent might be used in an occupation should be considered. Hobbies are often due to a source of talent and should not be overlooked in a self-appraisal. One might consider the following questions to determine special talents:

1. Do I write well?
2. Do I type well?
3. Am I a good speaker?
4. Do I play a musical instrument or sing well?
5. Am I mechanically inclined?
6. Can I perform physical feats well?
7. Can I work well with others?
8. Do I have a scientific and inquisitive mind?

Interests - Most people perform best when doing something they are interested in. A part of the personal inventory is to determine and understand self interest. This appraisal can be made by listing the things one likes best. These will be activities which excite the individual, things performed well, or in which one feels comfortable when doing. Consideration of the following may be helpful in developing the list:

1. Favorite subject(s) in school;
2. How spare time is spent;
3. School activities and clubs participation;
4. Social activities (church, youth organization, others) outside of school; and
5. Interest in people or things.

Most schools counselors provide students with interest inventory tests. After interests have been determined, the student should make certain that these interests are permanent and lasting. Sometimes interests change. Occupations that appeal to students are not always appealing after becoming a mature adult.

Physical Make-up - Different occupations have different demands on the health, strength, and stamina of individuals. Physical and health limitations should be

considered when making an occupational choice. Often persons with physical handicaps have been able to adjust and lead active, productive lives in occupations not adapted to their handicaps.

Educational Aspirations - Preparation is the key to success in a chosen occupation. An employer "buys" knowledge and skills when an employee is hired. A person needs salable skills, knowledge, and training to become employable. Much of the success of an employee depends upon competencies in a specific or related field of education or training.

A career choice should include plans for meeting the educational requirements of the occupation. It would be unwise to choose an occupation without preparing educationally. It would be foolish to try to become a mechanic without receiving the training.

Attitudes and Values - In a survey conducted of 100 of the largest companies in the United States, the company presidents ranked employee attitude as the single most important trait. It was ranked above possessed skills. Attitude is reflected in the treatment of others; the manner in which responsibilities are accepted; the perspective taken when faced with a problem; and the regards for job, supervisor, and company. A person with a good attitude will think positively, see the good in others, and will spend little time discussing unpleasant thoughts. Chances for success diminish with a poor attitude.

Values are those things that are important to a person. The values of parents and friends are imposed upon most young people. Some of these values will be retained, but others will be rejected. The amount of emphasis placed on different values changes throughout a person's life. Many of the things that are important today will be of little importance in later life. However, the present values held by a student will influence career plans. As a part of the self-appraisal of values, the student might consider the following questions:

1. Will my choice of an occupation agree with my attitudes and values?
2. Can I express my attitudes and values in my work?
3. Will the people I work with have similar attitudes and values?

If the answers to the above questions are yes, then the student's choice of an occupation would appear to be in agreement with the values held. If an occupation interferes with the individual's values, a choice must be made to either readjust the values, or seek another occupation.

Personality - This is a set of habits which a person develops in reacting to people and situations. It reveals the kind of person one is and determines to a great extent how other people see a person. The student should consider the following personality traits to determine the impression that is being made.

1. Attitude
2. Courtesy
3. Enthusiasm
4. Friendliness
5. Honesty
6. Initiative
7. Loyalty
8. Morality
9. Self-contact
10. Sense of humor

Self-Concept - Self-concept is the way one views himself/herself. A self-appraisal should include the way the students view themselves in relation to the people they are in contact with. An occupation should be selected that will provide one with a satisfying self-concept.

Willingness to Change - It is very important that a prospective employee be flexible and willing to change. Most all employees encounter situations that require adjustments. The success in an occupation may depend upon the employee's ability to accept constructive criticism and willingness to make the proper adjustment.

Previous Experiences - Previous work experience should be appraised to determine the types of work that have provided the student with the most success. Work experiences can increase present interest and develop into new interests. Knowledge and skills can also be acquired, which will be helpful in a future occupation. Previous work experience can be a good indicator of success in a career. Satisfying part-time work experience often leads to satisfying full-time positions.

Chart No. 1

A personal inventory form has been included for the student to record personal qualities. After completing this form, the student should have a good knowledge of his/her personal qualities and should consider one or more occupations that will fit these qualities.

6. Occupational Requirements

Occupations, like people, have many varied characteristics. Occupations that appeal to a person should be investigated as to their specific characteristics and examined in terms of what they have to offer and what the prospective employee can offer the occupation.

One can be much better prepared to plan a career if a study is made of the occupation and all facts are available. This is necessary in order to make a wise choice. The following discussion should be helpful in studying the various occupational requirements.

Transparency No. 3

Employment outlook - The business trends that might affect future employment, current and future demands of employees in the occupation, and salary and other

benefits should be determined. The local office of the State Employment Service should be able to provide this information. The above information is mailed to the state offices monthly by the U.S. Department of Labor.

Nature of Work - When considering possible career choices, it would be wise to become familiar with the nature of the work. A knowledge of the work performed will assist in comparing one occupation with another. The following questions pertaining to an occupation will assist in determining the nature of the work.

1. Work performed
   a. Physical activities performed?
   b. Tools and equipment used in occupation?
   c. Travel involved?
   d. Responsibilities that must be assumed?
2. Working conditions
   a. Environment in which work is performed?
   b. Exposure to hazardous or unpleasant working conditions?
   c. Whether work will be performed with others or alone?
   d. Supervision?
3. Working period or hours
   a. Regular or irregular hours?
   b. Shift, day, or night?

Qualifications - The occupational entrance requirements should be determined before making a career choice. A consideration of the following factors should be helpful in determining the entrance requirements:

1. Special aptitudes and interests required by occupations;
2. Educational level, training, and experience requirements;
3. Physical requirements; and
4. Personality characteristics required.

Entrance and Advancement - The occupational choice normally influences the state and area within a state in which one will live. After determining the areas in which one would seek employment, then the methods used to enter and advance in the occupation should be determined. Some employees are hired directly by the employer, while others are hired through employment agencies. Still others must have the approval of a labor union before becoming employed. It is important to be familiar with the procedure used.

In addition to determining the method for entrance, it is important to determine methods of advancement and requirements for advancement. Some jobs offer no advancement, while others offer many advancements.

Advancement usually depends upon a combination of factors such as size and type of business, personal qualities, interest in work, willingness to learn, and ability

to get along with fellow employees. Most occupations provide advancement opportunities in the form of higher pay after the employee proves himself/herself by accepting more responsibility and performing a greater variety of tasks. Chart No. 2 should be helpful in reviewing the requirements of an occupation.

CHART NO. 1 - PERSONAL INVENTORY FORM

Personal Data:

Name _____ Social Sec. No. _____

Address _____ Phone No. _____

Age _____ Sex _____ Height _____ Weight _____ Birth Date _____

Name of Father _____ Occupation _____

Name of Mother _____ Occupation _____

Do you live at home? _____ If not, where? _____ Are you married? _____

Church Preference _____ Military Status _____

Educational Background:

High School Attended _____ Grade Now _____

Rank in Class _____ List school subjects that
(Above average, Average, Below Average)

you have completed: _____

_____

_____

What subjects did you enjoy most? _____

_____ Least? _____

List school activity participation by years: _____

_____

List school clubs and offices held: _____

_____

CHART NO. 1 - PERSONAL INVENTORY FORM (CONTINUED)

How many years of vocational agriculture have you taken? _____

What other classes would be helpful for preparation for employment? _____

_____

List specialized training received in school: _____

Number of days absent from school or work? _____

Work Experience:

List the names of all previous employers, the length of time worked for each, and the reason for leaving: _____

_____

Health:

List any serious illness or operation that you have had: _____

_____

Are you physically handicapped? _____ Explain: _____

_____ Were you ever injured while working? _____ Explain:

_____

Name of family physician: _____

Person to notify in case of emergency: _____

Hobbies and Recreation:

List hobbies or recreation activities that you enjoy: _____

_____

CHART NO. 1 PERSONAL INVENTORY FORM (CONTINUED)

References:

List the names & addresses of three people whom you might use as a reference.

Do not include relatives. (Use teachers, ministers, employers.)

_____ _____

_____ _____

_____ _____

Other Information:

What do you think are your qualifications for becoming employed? _____

_____

What are your ambitions? _____

_____

_____

CHART NO. 2 - OCCUPATIONAL REQUIREMENTS

1. Place of employment _____
2. Employment outlook
   A. Present need for workers?
      (1) Locally -
      (2) In state -
   B. Future outlook? _____
   C. Employee turnover? _____
3. Nature of work
   A. Activities, duties, and responsibilities _____
      _____
   B. Working conditions _____
      _____
   C Working hours _____
4. Qualifications
   A. Mental abilities
      (1) Language skills _____
      (2) Writing skills _____
      (3) Mathematical skills _____
   B. Educational and training requirements
      (1) Location _____
      (2) Cost _____
   C. Physical requirements
      (1) Health _____
      (2) Strength _____
   D. Personal Characteristics
      _____
5. Entrance and advancement
   A. Certification or license _____
   B. Union membership, professional societies _____
   C. Salary _____
   D. Promotion, security, benefits _____

CONSEQUENCES OF OCCUPATIONAL CHOICE

the occupational choice may determine

- whether a person is employed, underemployed, or unemployed
- a person's associates
- success or failure
- whether one likes or dislikes his work
- a person's contribution to society
- area in which one lives
- choice of friends
- marriage partner
- school which children will attend
- mental health
- salary
- visits to other family members

PERSONAL QUALITIES AND THE WORLD OF WORK

- ability
- talents
- interests
- physical make-up
- educational aspirations
- attitudes and values
- personality
- self concept
- willingness to change
- previous experience

FACTORS TO CONSIDER IN DETERMINING OCCUPATIONAL REQUIREMENTS

employment outlook

trends, current and future demand for employees, salary, and other benefits

nature of work

work performed

physical activities, tools and equipment used, travel involved, and responsibilities

working conditions

environment, exposure to hazards, etc., work performed with others or alone, and supervision

working hours

regular or irregular hours, shift work, day or night work

qualifications

special aptitudes and interests; education, training and experience; physical; and personal characteristics

entrance and advancement

OCCUPATIONAL INFORMATION

Unit A: Opportunities in Agricultural Mechanics

Topic 3: Finding a Job and Preparing for an Interview

Suggested Procedures and Activities:

After completing the topic it is suggested that the letter, "Why the Other Boy was Hired" and the discussion on the boy who recommended himself be read to the class. These are at the end of the topic.

1. Finding a Job

Most employed individuals at sometime during their working years must seek a place of employment. "Job hunting" is a form of selling. The person applying for a job is selling skills or services. Competition for jobs is keen, and the salesperson having the most to offer is usually the one that is successful.

Studies have been conducted to determine the best methods of finding job vacancies. The following information is based on these studies:

Relatives and Friends - Successful job applicants are notified of job openings about 50 percent of the time by their relatives and friends. Many times jobs are filled by this method before the job opening is advertised or reported to the employment agency. However, equal opportunity employers (employers having non-discriminatory practices in the hiring, assigning, promoting, paying, etc.) are required to advertise job openings for a minimum length of time, which is generally two weeks.

Those looking for jobs should notify their friends and relatives that they are seeking employment. The job seeker, however, should not expect his friends and relatives to use their influence, or misrepresent the applicant's abilities and skills. The hiring of employees is an expense to the employer. Hiring of an incapable person increases expenses and causes a loss of confidence for relatives and friends.

Personal Contacts - This is the second most effective method of finding a job. To use this method, several firms are selected that are presently using skills and services comparable to those of the job seeker. Contact is made with the firm by either appearing in person or telephoning the firm's employment office.

Newspapers - Most all newspapers have a section with the heading, Job Opportunities. Many of the advertisements give a detailed description of the type of individuals the firm is hiring. The job seeker should be aware that the sooner the contact is made--

whether by letter, telephone, or personal contact--the better are the chances of obtaining the job. Another method of using the newspaper is to place an advertisement in the Situation Wanted section. When using this method, the applicant may be easily contacted by the prospective employer.

Contacts with Former Employers - This is often a good method of seeking employment if the job seeker performed well when employed by the firm and the termination of employment was amiable. This method is effective many times when no vacancy or job opportunity actually exists. The employer creates a position for the employee.

Employment Agency - The term "employment agency" is not restricted to the state employment service and includes the local school counseling service, community employment organizations, and private employment services. These agencies usually have trained placement personnel to assist the job seeker.

2. Letter of Application

Letters of application are useful both to the job seeker and to the employer. It is often used by the job seeker to determine if firms have job openings.

Employers use letters of application in several ways, some of which are to gain insight as to the ability of the applicant to express himself/herself in written form; to schedule interviews; to obtain background information as to the applicant's training, experiences, and qualifications; and as a means of selecting applicants to interview.

The importance of the letter of application cannot be over emphasized. Some situations in which letters should be written are as follows:

1. When applying for a business or professional position out of town;
2. When seeking an interview;
3. When answering a newspaper advertisement that requests a written application; and
4. When an employer requests a letter of application.

Since the letter of application is a means of selling one's self to an employer, it is necessary to create a good impression. The following should be helpful in composing the letter:

1. If possible, the letter should be written to a specific person and not merely to the firm.
2. All names should be spelled correctly. If necessary, a telephone call should be made to verify spelling.
3. The letter should be brief, original, and "to the point."
   a. Introductory remark in the letter should state the exact position or type

of position the applicant is seeking.

b. Details about ability and background are omitted. These are left for the interview. An accompanying outline of details (personal data sheet) is permissible.

4. The letter is typed or neatly written. A pencil is never used. Limit letter to one typewritten page, and compose short paragraphs.
5. Standard size paper (8½ inches by 11 inches) is used.
   a. Avoid erasures and write on only one side.
   b. Letterhead stationery is not used unless it is the applicant's.
6. Correct spelling and punctuation is a must.
7. The closing paragraph should be effective.
   a. A statement that the applicant would be glad to appear for an interview at the employer's convenience should be included.
   b. A business-like closing is used.

Chart No. 1 - Personal Data Sheet

A well-written letter of application may be all that is necessary to secure an interview. It may, however, be an advantage for the applicant to include additional information on a personal data sheet. This is the accepted way of presenting information not included in the letter of application. The personal data sheet might include a picture, information pertaining to family members, physical stature and general health, courses taken in school, work experience, performance skills, hobbies, and references.

Chart No. 2 - Written Application Forms

Applicants applying in person are normally asked to complete an application form. The usual practice, however, is to submit a written application form before the interview is scheduled. A copy of the applicant's personal data will be helpful in completing the application form. Also, the applicant should have at least three references. Permission should be obtained in advance to use the references. The job seeker should be aware that the employer will form an opinion of the applicant's neatness and ability to complete the form.

The following should be helpful in completing an application form:

1. Follow instructions. The form usually has instructions as to whether the applicant should write or print and use pencil or pen.
2. Write or print neatly and legibly. Keep form clean and free of erasures.
3. All questions are not applicable; the letters NA should be written in the space provided.
4. Questions should be understood before attempting to answer them.
5. Personal data sheet is used to complete application form.

3. Preparing for the Interview

The purpose of an interview is to verify the information in the application and to gain insight into the prospective employee. Personality, mannerisms, attitude, ambition, career plans, education, and work experience can be observed and verified. Detailed preparations for the interview should be made, since the time spent in the interview is some of the most valuable time the applicant will spend in securing a job.

The first impression is generally a lasting impression. The person being interviewed must make a favorable impression because there is only one personal interview. Much of the success or failure in securing the position is dependent upon the interview.

Personal interviews may be compared to selling. A good salesperson not only has a knowledge of her/his products but of competitive products. Questions can be answered about the products without hesitation. It is necessary, like a good salesperson, that the applicant be able to answer any personal question, either orally or in writing. Since the applicant is trying to sell a product, service, or skills, a knowledge of service and skills that can be rendered is important.

Product knowledge for the prospective employee may be secured by preparing a personal inventory. An example of a personal inventory form is provided in the topic, "Choosing an Occupation." Although the inventory will not be presented to the employer, it should be written in order that the applicant can review and study it.

After studying the personal inventory, the applicant may discover that he/she does not have the qualifications for the position. It is necessary to have the skills and competencies needed to perform the job for which one is applying.

Prior to the interview, the applicant should gather as much information as possible about the employer or firm. The locations of plants, kinds of products sold or manufactured, growth trends, and employment opportunities available are some facts that should be secured. This information is important regardless of the size of the firm. One method of securing this type of information would be from an employee of the firm.

The following are often asked during an interview and may be helpful in preparing for the interview:

1. What are your long range and short range goals and objectives, when and how did you establish these goals, and how are you preparing yourself to achieve them?
2. What specific goals other than those related to your occupation have you established?
3. Why would you like to work for our company?
4. What do you know about our company?

5. What qualifications or training do you have for this job?
6. What do you see yourself doing five years from now?
7. What are the most important rewards you expect in your career?
8. What do you expect to be earning in five years?
9. Do you feel that you have done the best scholastic work that you are capable of doing?
10. In what activities and clubs were you involved while in high school?
11. How many days were you absent from school or work because of illness?
12. Have you had any serious illness?
13. Do you smoke?
14. Do you drink alcoholic beverages?
15. Do you like routine work?
16. Do you like regular hours of work?
17. How do you feel about working overtime?
18. Do you prefer a specific geographic location?
19. Will you relocate? Does relocation bother you?
20. Are you willing to travel?
21. Are you willing to spend at least six months as a trainee?
22. What salary do you expect?
23. Have you had any difficulty getting along with fellow students and instructors?
24. What is your major weakness?
25. What major problems have you encountered and how did you deal with them?
26. What have you learned from your mistakes?
27. What two or three accomplishments have given you the most satisfaction? Why?
28. Describe the relationship that should exist between a supervisor and those reporting to him or her.
29. What qualities should a successful manager possess?
30. How do you determine or evaluate success?
31. In what way do you think you can make a contribution to our company?
32. How do you spend your leisure time?
33. What are your hobbies?

Some factors that one might consider in preparing for the interview and in creating a good impression on the day of the interview are as follows:

Things Needed During Interview - Pen and pencil, social security card, personal data sheet, personal inventory, and certification or work permit, if required, should be carried to the interview.

Exclusion - The applicant should go alone for the interview. Most employers resent persons applying in a group, or with another person, such as a parent, sitting in during the interview.

Physical Appearance - The employer's first impression will be based on the applicant's appearance. The applicant should be neatly dressed but not over-dressed for the job being sought. For some interviews, the male applicant

should wear a coat and tie, while for others an open shirt collar is proper. A female applicant in most instances should use "good taste" and dress reasonably conservative. Both males and females should be well-groomed and should refrain from smoking during the interview, unless the employer suggests that the applicant smoke.

Promptness - A good salesperson is on time for an appointment and does not keep the customer, or the employer in this case, waiting. A tardy applicant creates an unfavorable impression. If it is necessary to drive some distance for the interview, ample time should be allowed. The applicant also should not be too early. Arriving five to ten minutes before the scheduled time is considered to be adequate.

Office Manners - Many employers have secretaries or receptionists, and it will be necessary to spend a few minutes in their office before the interview. The applicant should introduce himself/herself to the secretary and tell her the purpose of the visit (for an interview) and that the applicant would like to see the employer when it is convenient. The applicant should also try to favorably impress the secretary. Some secretaries have considerable clout with their employers.

Entering the Employer's Office - If not introduced to the employer by the secretary, then the applicant should introduce himself/herself in a pleasant business-like manner. The interviewee's name is pronounced distinctly, and the applicant should not use Mr. or Mrs. in his/her introduction. If the employer offers to shake hands, the applicant should do so with a firm grip. The applicant should wait for an invitation to be seated before sitting down and should observe good posture while seated.

The Interview - Some interviews are informal and chatty and are nothing more than the employer observing the applicant's appearance and mannerisms. Still others may require considerable time and may involve the taking of tests to determine aptitudes and abilities.

After the applicant has been introduced, the interviewer is allowed to take the lead in asking questions and directing the course of the conversation. The interviewer is aware of the information needed. The first question or statement may concern information regarding the requirements of the job. The applicant's response should be brief, meaningful, and provide only information requested, unless an interest in additional information is indicated. Time should not be used by the applicant relating favorable information not related to the job. If the interviewer requests the applicant's personal folder, it should be provided; but the applicant should not shower the interviewer with documents on experiences and qualifications.

The applicant should be truthful, direct, and use proper English when answering questions. Slang is avoided. Qualifications are being sold, rather than a need

for work. The interviewer is interested in what the applicant can do rather than how badly work is needed. Initiative should be shown, rather than the applicant's concern for salary and other employee benefits. The applicant should not tell jokes or be overly friendly, but should be agreeable and act as one would normally. Any papers on the desk belong to the interviewer and no attempt should be made to read them.

Some questions during the interview may be intentionally personal and blunt in order to test the applicant's reaction and tact. Other questions may be asked to determine social or moral attitudes, as well as concerning job knowledge. If a matter of a controversial nature is discussed, the best policy is to answer briefly without showing emotions or giving a strong personal opinion either way. Normally, a good rule to follow if a pleasant statement cannot be made about a situation or topic is to say very little or nothing. This is particularly true if the subject pertains to school or a former employer. If it becomes necessary to explain a situation that is not totally desirable, the applicant should avoid saying anything that will appear to be a complaint.

The interviewer should end the interview; however, if there are points of interest concerning working hours or other specific information that have been overlooked, the applicant should feel free to ask questions. It is a good idea not to appear overly anxious, but in order to make an intelligent decision, it is necessary that the applicant be well-informed. Most interviewers encourage applicants to ask questions concerning the firm and its policies. These are sometimes left to near the end of the interview.

The applicant should be alert in determining the close of the interview and should leave as soon as it is completed. It is proper at the close to express appreciation for the time and consideration given.

Some mention of future contact is usually made by the interviewer. If this is not mentioned, the applicant may ask if a future contact will be made, in what manner, and how.

It is not a common practice to offer the applicant the job during the interview because the interviewer may wish to interview other applicants or check references. However, the applicant may be offered the job during the interview.

It is proper for the applicant to follow-up on jobs that appear encouraging. This is accomplished by writing a note of appreciation to the interviewer. The note will serve as a reminder of the interview.

The applicant should not be disappointed if the impression desired is not made during the interview. The best salesperson does not make every sale. An interview with another firm should be scheduled, and the applicant should learn from any mistakes made during the previous interview. A better impression

should be made at the next interview. The following rating sheet could be useful in evaluating an interview.

Chart No. 3

Most large firms employ full-time personnel managers and assistants who have the responsibility of hiring new employees. These firms are constantly seeking new employees. However, the firms expect the prospective employee to seek the job. One should not be reluctant to apply for a position that appears to be desirable; that is, if the applicant has the qualifications.

4. Letter, Why the Other Boy was Hired

The following letter was written by Donald E. Wood to a teenage boy who applied for a job. It is included to help prospective employees see how some employers look at young job applicants.

Dear Kid:

Today you asked me for a job. From the look of your shoulders as you walked out, I suspect you've been turned down before, and maybe you believe by now that kids out of high school can't find work.

But, I hired a teenager today. You saw him. He was the one with polished shoes and a necktie. What was so special about him? Not experience, neither of you had any. It was his attitude that put him on the payroll instead of you. Attitude, son. A-T-T-I-T-U-D-E. He wanted that job badly enough to shuck the leather jacket, get a haircut, and look in the telephone book to find out what this company makes. He did his best to impress me. That's where he edged you out.

You see, Kid, people who hire people aren't "with" a lot of things. We know more about Bing than about Ringo, and we have some Stone-Age ideas about who owes whom a living. Maybe that makes us prehistoric, but there's nothing wrong with the checks we sign, and if you want one you'd better tune to our wave length.

Ever hear of "empathy?" It's the trick of seeing the other fellow's side of things. I couldn't have cared less that you're behind in your car payments. That's your problem. What I needed was someone who'd go out in the plant, keep his eyes open, and work for me like he'd work for himself. If you have even the vaguest idea of what I'm trying to say, let it show the next time you ask for a job. You'll be head and shoulders over the rest.

Look Kid: The only time jobs grew on trees was while most of the manpower was wearing G. I.'s and pulling K. P. For all the rest of history you've had to get a job like you get a girl: "Case" the situation, wear a clean shirt, and try to appear reasonably willing.

Maybe jobs aren't as plentiful right now, but a lot of us can remember when master craftsmen walked the streets. By comparison you don't know the meaning of "scarce."

You may not believe it, but all around you employers are looking for young men smart enough to go after a job in the old-fashioned way. When they find one, they can't wait to unload some of their worries on him.

For both our sakes, get eager, will you?

Donald E. Wood

5. The Boy Who Recommended Himself

A gentleman advertised for a boy to assist him in his office, and nearly fifty applicants presented themselves. Out of the number, he selected one and dismissed the rest.

"I should like to know," said a friend, "on what grounds you selected that boy, who had not a single recommendation."

"You are mistaken," said the gentleman. "He had a great many. He wiped his feet when he came in, and closed the door after him, showing that he was careful. He gave his seat, instantly, to that lame old man, showing that he was kind and thoughtful. He took his hat off when he came in and answered my questions promptly, showing that he was polite and gentlemanly. He picked up the book which I had purposely laid on the floor and replaced it upon the table, while all the rest stepped over it, showing that he was orderly. He waited quietly for his turn, instead of pushing and crowding. While I talked to him I noticed that his clothing was tidy, his hair neatly brushed, and his finger nails clean. Do you not call these things recommendations? I do."

This story was taken from a book by George W. Gerwig entitled, "Ambition-Guideposts to Character," published by the American Book Company, New York.

Reference:

"Group Instruction Handbook," Vocational Instructional Services, Texas A&M University, College Station, TX 1975.

CHART NO. 1 - PERSONAL DATA SHEET

Name _____ Soc. Sec. No. _____
Address _____ Res. Telephone _____
_____ School Telephone _____
Age _____ Date of Birth _____
(Month/Day/Year)

Health

Family physician _____ Your height _____ Your weight _____
List illnesses or operations in recent years _____
_____
List and describe physical handicaps _____
_____

Education

	Name of School	City	Date Graduated
Elementary			
High school			
Trade School			
Other			

Hobbies

_____

Extracurricular Activities

_____
_____

References

	Name of Person or Firm	Address	Telephone
1.			
2.			
3.			

Work Experience

	Name of Firm	Address	Dates of Employment
1.			
2.			
3.			

CHART NO. 2 - SAMPLE LETTER OF APPLICATION

Box 100
Farmville, U. S. A.
September 20, 1979

Mr. John McAhee, Manager
Brown Farm Implement company
340 Main Street
Farmville, U. S. A.

Dear Mr. McAhee:

Mr. Andrews, teacher of vocational agriculture at Farmville High School, has informed me of a vacancy in the tractor and machinery parts department of your firm. I would like to submit my name for consideration for this position.

At present, I am a senior enrolled in the cooperative part-time training program at Farmville High School and will be available for employment after 2:00 p.m. on school days, and the entire day on Saturdays and during the summer.

I have lived and worked on a farm all my life. Last summer I worked in the parts division of the Farmville Tractor and Equipment Company. I have served as secretary of the local FFA Chapter and rank scholastically in the upper fourth of my high school class.

I am interested in a career in agricultural machinery sales and recognize the value of being associated with a firm of your reputation. I would appreciate a personal interview with you at your earliest convenience so you may become better acquainted with my qualifications. I will be available for an interview after 2:00 p.m. on school days and any time on Saturdays.

I may be contacted at the above address or through Mr. Andrews at the high school. I am looking forward to your reply.

Sincerely,

John Jones

CHART NO. 3 - RATING SHEET FOR PERSONAL INTERVIEW

Name _____ Job Applied For _____

Check the answer which you think is most appropriate for the following questions:

Yes	No	
		1. Arrived on time
		2. Introduced himself properly (stood erect and looked interviewer in the eye during introduction)
		3. Waited for invitation to be seated
		4. Answered questions clearly and concisely
		5. Had all proper credentials (social security card, personal data sheet, work permit - if applicable)
		6. Was generally familiar with the company (wage scale, nature of work, reputation of the company, competition in the field, etc.)
		7. Asked pertinent questions about the company
		8. Used reasonably good English

(Check one)	Above Average	Average	Below Average
1. Appearance	_____	_____	_____
2. Interest	_____	_____	_____
3. Maturity	_____	_____	_____
4. Anticipated competence	_____	_____	_____
5. Attitude	_____	_____	_____

Comments:

Recommendations:
1. _____ Hire
2. _____ No Interest
3. No interest, suggest interview with _____

Evaluator _____ _____
(Signature) (Date)

OCCUPATIONAL INFORMATION

Unit A: Opportunities in Agricultural Mechanics Occupations

Topic 4: Employee - Employee and Employee - Employer Relations

Suggested Procedure and Activities: While discussing this topic, use actual case situations in the class. Community employers and employees may also be used as resource speakers.

1. Introduction

The degree of success attained by a worker on the job is largely dependent upon three things: the ability to skillfully perform job duties; the possession of certain knowledge and understandings; and the ability to get along well with people contacted on the job. On the part of the employee, skills and knowledge are important, but cannot overcome the handicap of poor human relations. By the same token, employers who ignore the principles of good human relations are plagued with disgruntled workers and usually have a high rate of labor turnover. A good on-the-job relationship is a two-way affair requiring thoughtfulness, consideration, and fair play on every hand.
Transparency No. 1

2. Facts Concerning Employee-Employee Relations

a. Most occupations deal with machines, equipment, or paper work; that is, they deal with things. In business, however, most of the jobs involve close contact with people.

b. As a group, people are very much different. Each person is an individual. It is possible for things that appeal to one person to be distasteful to others.

c. Three things people have in common are: right to work at a job of own choice; desire to get ahead; and desire to be accepted and approved of.

d. Routine duties should be performed along with the so called "important jobs" to the best ability of the worker. Along with doing a job well, it is important to learn as much as possible about the total business operation.

e. An employee should exhibit the following traits: tact, sense of humor, initiative, enthusiasm, team spirit, loyalty, ability to take constructive criticism, and respect for other individuals.

f. The total morale of a business operation is not up to the boss alone; it depends upon each individual employee.

g. A desirable employee will avoid joining a clique, be willing to learn, and show appreciation to fellow workers.

h. The primary objective of all employees is to make a living. But in addition to this, there are other satisfactions in a job. These might be social status or psychological needs. All employees like to feel that their job is important.

3. Responsibilities of the Employer to the Employee

Transparency No. 2

a. The employer provides a place to work and, in most cases, equipment to work with. This often includes land, facilities, tools, and equipment which require a sizable investment.

b. An employer does not expect a new worker to be fully productive until he or she has been trained for the job. The employer usually loses money while a beginner is being trained. The employer may invest many more dollars in training an enterprising worker for a supervisory position.

c. An employer should provide pleasant surroundings in which to work. In addition to providing adequate space and equipment, many employers provide food facilities or allowances and recreational activities for their employees.

d. The employer is responsible for salaries and other financial benefits. These may include various forms of insurance (medical, life, accident, unemployment), advancement, retirement plans, holidays and vacations, discounts on purchases, and handling of income tax and social security accounts.

4. Responsibilities of the Employee to the Employer

Transparency No. 3

Employers expect cooperation and dependability from employees in return for salaries and benefits. The following attitudes and characteristics are expected on the part of the employee:

a. Honesty means more than just not taking things which do not belong to one. It means giving a fair day's work for a fair day's pay or carrying out one's side of a bargain. Honesty also dictates that one's words convey true meanings and actual happenings.

b. Loyalty implies support of a cause, ideal, practice, or custom. It means being "for" a person or an organization, and that is a two-way proposition. Employees expect employers to look out for their interests, to provide them steady employment, and to promote them to better jobs as openings occur. Employers feel that they, too, have a right to expect their employees to be "for" them-to keep their interests in mind, to speak well of them to others, to keep any minor troubles strictly within the plant or office, and to keep absolutely confidential all matters that pertain to the business. Perhaps both employers and employees should keep in mind that loyalty is not something to be demanded; rather, it is something to be deserved.

Loyalty takes time to mature and grow. It is the product of continued contact with a person or business over a period of time. New employees should not expect to receive this loyalty before proving themselves worthy of their supervisor's faith and confidence. Likewise business firms must earn loyalty from their employees. The good will and loyalty which develop between supervisors and employees are valuable commodities, which are not to be treated lightly.

c. Willingness to learn - Almost every different kind of agricultural business will have its own way of doing things. Employers expect their employees to be willing to learn these ways. Sometimes the installation or use of new equipment or machines makes it necessary for even experienced employees to learn new methods and operations. It will be noted that workers who are promoted to jobs with greater responsibility are usually those who have taken the time and trouble to learn about more than just their own daily tasks.

d. Willingness to take responsibility - Most employers expect their employees to see what needs to be done, then go ahead and do it. It is very tiresome to have to ask again and again that a certain job be done. When an employee is given directions about how do a job, then he is expected to follow them exactly. It is generally true that responsibility should be delegated and not assumed; however, once the responsibility has been delegated, the employee should continue to perform the duties without further direction.

e. Respect for authority - Authority in agricultural businesses usually rests in managerial positions which are responsible for production, sales, or service, as the case may be.

Authority is the power or right to give commands, take actions, or make final decisions.

Most agricultural businesses are relatively small and uncomplicated. Yet, the concept of respecting your superior is an important one, even in a small business.

f. Ability to get along with people - This is perhaps the most highly prized of all employee traits. To some the ability to get along well with people seems to come as a gift; to others, it comes only as a result of painstaking thought and training. In order to acquire this ability, one must learn to think of people as individuals, to be able at times to put oneself in another person's place, and to want sincerely to get along with others. Once acquired, the ability to get along well with people pays big dividends in friendships, popularity, and profits. Employers are ever appreciative of the employee who is "easy to get along with."

g. Willingness to cooperate - The employer who pays the salary has a right to expect full cooperation of the employee. One of the best ways to show a cooperative attitude is to offer to help other employees when one's assigned duties have been completed. In many companies there are certain tasks that nobody likes to do. The employee who is willing to do these tasks will make a good impression on the boss and also gain the cooperation of fellow workers. One should learn to work as a member of a team with employer, supervisors, and fellow workers in a common effort to get the work done pleasantly and on time.

h. Rules and regulations - Not even two people can work together well unless there is some understanding as to what work shall be done, when it is to be done, and who shall do it. Rules and regulations are a necessity in any work situation, and should be so considered by all employees.

i. Tardiness and absenteeism - Tardiness means being late to work, and absenteeism means being off the job for one reason or another. Both are poor work habits and lead to reduced production. Failure to get to work on time results in confusion, lost time, resentment on the part of those who do come on time, and may lead to a reprimand or even a dismissal. It is true that a few minutes out of a day is not important, but a principle is involved. The employee agrees to terms and conditions when accepting a job.

It is sometimes necessary to take time off from work. No one should be expected to work when sick, or when there is serious trouble at home which demands attention. However, it is possible to get into the habit of letting unimportant and unnecessary matters come before the job. This results in lost production and hardship on those who try to carry on the work with less help. Again there is a principle involved. The employer has a right to expect employees to be on the job unless there is some very good reason for staying away. If it is necessary for an employee to miss work, it is the responsibility of that person to notify the employer or supervisor.

j. Termination of employment - Legally and rightfully there are several ways in which relations between employer and employee may be terminated. In many cases the condition of employment is set forth in a contract signed by the worker or his representative and the employer.

When employment is based upon contracted relation, then both employer and employee are bound by the same laws that validate any contract. Should either employer or employee take the liberty of breaking the contract that exists, it makes the guilty party liable to the offended party.

There exists in the present employer-employee relations an "unwritten law, sometimes called "gentlemen's agreement", which deals with the termination of employer-employee relations. This is called "due notice" to employer by employee, and "due notice" to employee by employer. Most employment today is based upon the "unwritten law." This tends to serve the following purposes: (1) it does not bind an employee for a long period of time to a job for which he has no interest or ability; (2) it does not force an employer to continue to pay an employee whose services are detrimental to his business; (3) it allows both employer and employee time to make adjustments before termination without jeopardizing either; and (4) it serves as a means of keeping both employer and employee respectful and honest with each other.

From the employer's standpoint an employee may be discharged from his job even though there might exist between the two a legal contract. The following acts are reasons for justifiable discharge on the part of the employer: willful disobedience, disloyalty, incompetency, and nonperformance.

5. Employee Self-Evaluation

Feelings and attitudes between persons affect the productivity of the employee group. One employee who is not satisfied may influence others. Undesirable influence may spread through the entire group.

It is probably true that most people want to get along well with others, but don't really know how. The following are self-evaluation questions an employee may ask:

a. Am I willing to help the other fellow?

b. Am I willing to go halfway to be friendly?

c. Do I become irritable or show annoyance when changes or mistakes occur?

d. Do I try to be fair?

e. Do I hold grudges?

f. Do I give the other fellow the benefit of the doubt?

g. Do I talk more about the good than the bad qualities of others?

h. Do I think only of my own interests?

i. Do I take myself or my work too seriously?

j. Do I value my own integrity (character)?

k. Can I take authority?

Reference:

"Group Instruction Handbook, Cooperative Part-Time Training", Vocational Instructional Services, Texas A&M University, 1975

EMPLOYEE-EMPLOYER RELATIONS

- be tactful
- keep sense of humor
- show initiative
- have enthusiasm
- have team spirit
- be loyal
- take constructive criticism
- have respect for other individuals

RESPONSIBILITIES OF THE EMPLOYER

- provide place to work
- provide equipment to work with
- provide training
- provide pleasant atmosphere
- provide salary
- provide benefits

RESPONSIBILITIES OF THE EMPLOYEE

- be honest
- be loyal
- be willing to learn
- be willing to take responsibility
- respect for authority
- ability to get along with people
- be willing to cooperate
- follow rules and regulations
- be on time for work
- avoid absenteeism
- fulfill contract or work agreement

OCCUPATIONAL INFORMATION

Unit A: Opportunities in Agricultural Mechanics Occupations

Topic 5: Employee Benefits and Payroll Information

Suggested Procedure and Activities: A comparative study of farm and ranch mechanical jobs can be made using community and surrounding area resources and actual case situations.

1. Introduction

Job benefits and privileges have been expanded by most employers; therefore, these considerations are important in job selection. The individual seeking employment should calculate the value of benefits and privileges. In most instances, they are figured as a part of the total cost of employment along with salary. Most benefits and privileges are due to the fact that the employer and employee jointly finance the cost by payroll deduction on the part of the employee and contribution on the part of the employer.

The location of employment, the work schedule, the working conditions, and the salary are primary considerations in job selection. Job seekers must match themselves with opportunities available. Benefits and privileges are to be considered in the final selection of a job. School counselors, teachers, parents, and friends can offer sound advice to young people entering the job market. Salaries paid to workers depend upon state and federal minimum wage laws, the "going rate" for the type of job, and the ability of the worker to perform the job. Part-time and beginning workers cannot expect to earn as much salary or enjoy the same benefits as the experienced full-time employee.

Transparency No. 1

It is important that employees understand the cost and value of benefits available. These benefits and privileges include: insurance plans, retirement plans, social security programs, housing allowances, travel allowances, sick leave, vacation, and holidays.

2. Insurance Plans

Health insurance programs have three functions : (a) protect the insured against financial hardships due to illness or injury; (b) cover the cost of medical care in order to assure competent treatment; and (c) protect creditors by insuring the policy holder's ability to repay debts. Health insurance is commonly divided into two coverage areas; the more frequent minor expenses and the less frequent major expenses. The prospective insurance buyer must decide which of the two

areas, or both, to insure against. The basic health plan usually covers hospital, surgical, and physician's services up to a determined amount. The major medical plan is designed to take up where the basic plan left off. It is designed to handle large medical expenses, up to one million dollars in some cases. The major medical plan usually has a deductible amount to be satisfied and then will pay a percentage of the remaining cost.

Disability income insurance plans offer protection against salary loss as a result of sickness or accident, with varying amounts of annual benefit. The varying amount is up to seventy-five percent of an employee's earnings.

Life insurance is unique in that it treats each person's eventual death as "risk". Even though death is a certainty, when it will occur is not known. Life insurance works because the cost of one person's death and the resultant expenses incurred are distributed to a large number of persons. There are two basic reasons for owning life insurance : (a) provides protection against loss of income due to the premature death of the breadwinner and (b) allows for systematic savings and investment.

The first concern of life insurance is family protection in case of the untimely death of the head of the household. Certain expenses must be paid in connection with any death. These might include medical bills, burial expenses, settlement of debts, estate settlements, or even finding a new place to live.

The second concern of life insurance is to provide money for retirement in later years or for education of children. A life insurance program should be selected that will provide both death benefits and living benefits.

3. Retirement Plans

Retirement plans are usually based on age, years of service, and the salary drawn by the employee. Retirement plans which are totally financed by the employer usually terminate when the employee leaves the employer. On the other hand, some plans which provide for both parties sharing will return to the employee all contributions, together with interest which was earned during the period. Most retirement plans specify a minimum number of years of service and minimum age before an employee is eligible for retirement.

An example formula for a retirement plan is as follows: a worker who retired at age 65 with 42 years of service and an average salary for 5 years of $10,000 earns retirement benefits as indicated.

Transparency No. 2

$10,000	x	2%	x	42 years	=	$8,400
Average of 5 Years Highest Salary		Percent Average Salary		Years of Service		Annual Retirement Payment

The benefits are usually paid on a monthly basis and would in this case be $700 per month.

4. Social Security

Social security is the nation's basic method of providing a continuing income when family earnings are reduced or stop because of retirement, disability, or death. Today, ninety percent of the workers in the United States are earning protection under social security, and one out of seven persons are receiving monthly social security checks. About 22.8 million people, age 65 and over, have health insurance under Medicare. Another 2.6 million disabled people under 65 also have Medicare.

Social security benefits under the Federal act passed in 1935, and as amended since, provide coverage for industrial workers, self-employed persons, most state and local employees, members of the Armed Forces, members of the clergy, and household and farm employees. A farm employee is covered by the Social Security Act if an employer pays him $150 or more in cash wages during the calendar year for agricultural labor. The law also covers a farm employee who performs agricultural labor for an employer for twenty or more days during the year for cash wages figured on a time basis.

Monthly social security checks may go to workers and their dependents when the worker retires, becomes severely disabled, or dies. Medicare helps to pay the cost of health care for eligible people who are 65 or over or disabled.

A worker may receive retirement benefits as early as age 62, but at a reduced rate.

Disability benefits may be obtained before age 65 if the worker has a physical or mental condition that will prevent him from working for at least 12 months, or is expected to result in death.

Survivor benefits go to certain members of the worker's family. A lump-sum payment also can be made when a worker dies. This payment usually goes to the widow or widower. Unmarried dependent children are also eligible for survivor benefits.

Medicare has two parts - hospital insurance and medical insurance. The hospital insurance helps pay the cost of inpatient hospital care and certain types of follow-up care. The medical insurance part helps pay the cost of physicians' services and outpatient hospital services. People having the medical insurance pay a monthly premium of $8.20 as of July 1978.

Transparency No. 3

Employees and employers each contribute equal percentages on the employee's wages. Contribution rates and limits are scheduled as shown here:

1978- 6.05 percent on earnings up to $17,700
1979- 6.13 percent on earnings up to $22,900

1980- 6.13 percent on earnings up to $25,900
1981- 6.65 percent on earnings up to $29,700

Self-employed persons contribute on the same limit of earnings as do employers and employees. However, the percentage rate differs; in 1978 the self-employed person contributed 8.10 percent and in 1981 the rate will increase to 9.30 percent.

Transparency No. 4

In figuring monthly retirement checks, the retired or disabled person must meet eligibility requirements. The amount of the monthly check will depend upon several factors including age and average yearly earnings.

Examples of monthly social security payments are as follows:

(a) A retired worker age 65 with average yearly earnings covered by social security of $4000 would receive approximately $278.00.

(b) A retired worker age 62 with average yearly earnings covered by social security of $4000 would receive approximately $222.00.

5. Income Tax

Transparency No. 5

Income taxes are the largest source of Federal revenue. In 1977, 39¢ of each budget dollar received by the Federal government was from individual income taxes. The remainder of the budget dollar came from the following sources: 13¢ from corporation income taxes; 27¢ from social security taxes and contributions; 12¢ from borrowing; 4¢ from excise taxes; and 5¢ from other sources.

Transparency No. 6

Government revenue provides a wide range of services. The taxes an individual pays provide services which, in most cases, the individual could not afford. The following is a breakdown of how the Federal government budget dollar was spent in 1977: Income Security-33 1/2¢; National Defense - 24¢; Health - 10¢; International Affairs - 1 1/2¢; General Science - 1¢; Natural Resources, Environment, and Energy - 3 1/2¢; Agriculture - 1¢; Commerce and Transportation - 3 1/2¢; Community and Regional Development - 2¢; Education, Training, and Social Services - 5¢; Veterans Benefits and Services - 4¢; Law Enforcement and Justice 1¢; General Government - 1¢; Revenue Sharing - 2¢; and Net Interest - 7¢.

The income tax system in the U. S. is based on voluntary compliance; each person pays taxes and files a return. Income taxes are paid in the form of

withholding taxes from employee's paychecks. Self-employed persons and others pay estimated taxes each quarter and/or annual taxes at the time their tax returns are filed.

An employee should complete Form W-4, Employee's Withholding Allowance Certificate, when starting a new job or at any time when exemptions change. Many students and part-time employees have no tax liabilities due to their income, and therefore should claim exemption from withholding taxes and no deduction for income tax will be taken from their pay checks.

Transparency No. 7

In 1977, the following chart was used to show the minimum amount of gross income to be received before being required to file a tax return:

Single	$2950
Single (age 65 or over)	$3700
Married filing a joint return	$4700
Married filing a joint return (one spouse age 65 or over)	$5450
Married filing a joint return (both spouses age 65 or over)	$6200
Married filing a separate return	$ 750
Surviving spouse with dependent child	$3950

In addition:

- Person receiving tips from which social security taxes were not withheld
- Self-employment income of $400 or more
- Gross income of $750 or more, had any unearned income, such as dividends or interest from savings accounts, and can be counted as a dependent by parents. This is particularly important to students.

April 15 is the due date on which most taxpayers must file their returns. The tax return should be mailed to the appropriate Internal Revenue Service Regional Office.

6. Fringe Benefits

Transparency No. 8

Additional benefits may be provided by the employer for the purpose of making employment more convenient and attractive to the employee. It should be understood that the additional benefits and privileges carry with them certain respon-

sibilities. The following are common job fringe benefits:

(a) Housing Allowance - Allowances are sometimes made for employees who are forced to move due to job requirements or transfer. In addition, some employers may furnish a house and utilities and possibly meat for family consumption.

(b) Travel Allowance - Allowances for travel are usually paid when employees are required to be away from their regular headquarters in order to perform assigned duties. These allowances include mileage for transportation, cost of meals, and cost of lodging. In addition, some employers may furnish a vehicle for use by employees.

(c) Sick Leave - Sick leave privileges are provided by the employer to protect the employee's salary during the time that illness prevents him from being on the job. Beginning employees usually receive basic sick leave days per month and the rate of accumulation is usually determined according to years of service.

(d) Vacation - Often referred to as annual leave for employees who enjoy their work but plan to be away from it periodically with their family and friends. This privilege actually means fewer work days per year. If the vacation time is paid, the employer not only gets a break from work but receives financial compensation.

(e) Holidays - Certain days during the year are set aside to commemorate historical events. Many employers allow employees time off with pay to celebrate these events.

References:

Atherton, J. C. and Mumphrey, A., Career Planning and Development, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1969.

"Group Instruction Handbook, Cooperative Part-Time Training", Vocational Instructional Services, Texas A&M University, 1975.

"Your Social Security", HEW Publication No. (SSA) 78-10035, February 1978.

"Your Federal Income Tax", Publication 17, Internal Revenue Service, 1978 Edition.

"Understanding Taxes 78", Publication 21, Internal Revenue Service, 1978.

EMPLOYEE BENEFITS
AND
PAYROLL INFORMATION

- insurance
- retirement
- social security
- income tax
- housing allowance
- travel allowance
- sick leave
- vacation
- holidays

EXAMPLE RETIREMENT FORMULA

average of 5 years highest salary	X	per cent average salary	X	years of service	=	annual retirement payment

case situation: retired worker age 65
42 years of service
5 year average salary $ 10,000

$ 10,000 x 2% x 42 = $ 8,400

monthly retirement payment $ 700 (8,400÷12)

SOCIAL SECURITY RATES AND SALARY LIMITS

year	percentage	annual earnings up to -
1978	6.05	$17,700
1979	6.13	$22,900
1980	6.13	$25,900
1981	6.65	$29,700

EXAMPLES OF MONTHLY SOCIAL SECURITY PAYMENTS (effective June 1977)

benefits can be paid to a :	average yearly earnings after 1950 covered by social security		
	$3000	$5000	$8000
retired worker age 65	$236.40	$322.50	$453.10
spouse age 65	$118.20	$161.30	$226.60
spouse age 60 if sole survivor	$169.10	$230.60	$324.00
spouse with one child in care	$354.60	$483.80	$679.80

SOURCE OF 1977 FEDERAL BUDGET DOLLAR

individual income taxes	39¢
corporation income taxes	13¢
social security taxes	27¢
borrowing	12¢
excise taxes	4¢
other sources	5¢
total	$1.00

HOW THE 1977 GOVERNMENT DOLLAR WAS SPENT

income security	33½¢
national defense	24¢
health	10¢
international affairs	1½¢
general science	1¢
natural resources, environment, and energy	3½¢
agriculture	1¢
commerce and transportation	3½¢
community and regional development	2¢
education, training, and social services	5¢
veterans benefits and services	4¢
law enforcement and justice	1¢
general government	1¢
revenue sharing	2¢
net interest	7¢
total	$1.00

1977 INCOME TAX REQUIREMENTS

filing status	gross income to be received before required to file return
single	$2950
single(age 65 or over)	$3700
married filing joint return	$4700
married filing joint return (one spouse age 65 or over)	$5450
married filing joint return (both spouses age 65 or over)	$6200
married filing separate returns	$750
surviving spouse with dependent child	$3950

filing date : April 15

FRINGE BENEFITS

- housing allowance
- travel allowance
- sick leave
- vacation
- holidays

CONSTRUCTION AND MAINTENANCE

Unit A: Introduction

Topic 1: Shop Rules and Regulations

Suggested Procedures and Activities: Shop rules and regulations should be displayed and a printed list may be presented to the student during the discussion to become a part of the course notebook.

1. The Importance of Studying Agricultural Mechanics

   a. It is an accepted reality that the world is dependent upon mechanization or machine power to supply modern man with security, whether it be food, clothing, or shelter. The agriculturalist who does not know how to repair and maintain home conveniences, adjust farm machinery, remodel a building, repair a fence, use a farm level, and maintain electrical equipment may be recognized as an individual who needs more mechanical knowledge and skill to be a better farmer.

   b. Mechanical knowledge and skills are very important for the following reasons:

      Save the labor cost (50 percent of the cost of the article) on a needed project or repair job.

      Make project or construction plans and figure materials needed.

      Learn a skill by doing, and be better prepared to use the proper tools and equipment for the job.

      Save time on a job that requires immediate attention.

      Build projects needed for the supervised experience program.

      Make dependable judgments regarding machinery adjustments and needed repairs.

      Recognize quality work on any type of agricultural mechanics project and take pride in good workmanship.

      Make estimates as to the cost of construction or repair jobs.

      Help other students and friends on mechanical problems. Be able to demonstrate shop skills.

Adjust to mechanical problems that arise after graduation.

Develop a home shop for the purpose of constructing needed projects and making repairs locally.

Form habits of neatness, industry, accuracy, and carefulness -- an asset to the trade and individual.

Serve as a good unspecialized mechanic, not as a specialist or expert. Commercial shops are equipped to perform specialized jobs, such as a complete tractor overhaul.

2. The Importance of Rules and Regulations

a. Agricultural mechanics is a very important phase of the vocational agriculture program. Everyone enrolled in vocational agriculture has an opportunity to participate in the agriculture shop training program, and those enrolled in the shop program should demonstrate mechanical growth by improving their proficiency in shop skills. If the objective - to improve the mechanical ability in shop skills - is to be realized, then it is necessary that standards be developed to support a good agricultural mechanics program.

b. Good agricultural programs are based upon standards which are partially supported by rules and regulations; agricultural mechanics is no exception. There must be rules in a shop program. Good habits are developed by conforming to good rules. The purposes of shop rules are:

To protect the learner while a skill is being learned.

To protect expensive equipment and hand tools.

To keep tools and equipment available and in condition for teaching skills.

To develop skills by using the tools and equipment properly.

To learn to respect properly conditioned tools and equipment and good workmanship.

To develop skills by drawing shop plans, figuring bills of materials, budgeting time, buying building materials, and constructing projects.

To develop a shop type behavior.

To learn to appreciate the value of good housekeeping practices.

To prepare and keep a good notebook and records.

To have a thorough understanding of the purpose of the agricultural mechanics program.

3. Common Rules Observed in Agricultural Mechanics

a. Shop Safety - Safety rules are intended mainly to protect the shopworker, but they also protect the tools, equipment, and building. For example, if the worker fails to use the blacksmith's hammer on a cold chisel, and instead uses a claw hammer and pieces of the face break off, injuring the worker's face and shattering a window, shop safety has not been observed. Shop safety will be discussed in the next lesson.

b. Use of Shop Tools, Equipment, and Building - The purpose of the shop is to train the individual in shop skills; therefore, tools and equipment should be used properly at all times so that they will be available for use when needed. Proper use of the shop facility will lead to the following results:

The shop will be used only under proper supervision.
Shop tools, equipment, and supplies will remain in their proper place.
Tools and equipment will remain in a condition for training purposes.

c. Shop Behavior - Scuffling or horseplay endangers not only those involved in the act, but everyone in the shop. Loud conversation is distracting in the shop or the classroom. Walking instead of running is considered a must in shop rules. Talking to a classmate who is working with tools or equipment may create an accident or injury due to the individual being distracted from the work. Only tools that are approved by the teacher or instructor should be used.

d. Building a Shop Project - If the project is large it may require the drawing of a project plan, listing needed materials, and securing approval of the teacher and parents before beginning the actual work. It is considered a good practice to learn certain shop skills by first building the required shop project before constructing a personal project. All projects must show quality of workmanship.

e. Shop Program Schedule - Generally speaking, most of man's daily activities are based upon a time schedule. There must be a shop schedule if desired skills are to be learned while completing shop projects.

Time is an important factor, and it must be used wisely if progress is to be made in the shop schedule. Time must be considered in the shop activities list below.

Any shop assignment, including lessons, should be completed as soon as possible, but quality should not be forfeited entirely for the sake of time.

There is a limit on the amount of time it takes to complete a shop project. Time is given to complete a drawing, figure a bill of materials, purchase

the materials, and build the project. Remember, working with speed and accuracy is also an important skill to develop in the shop.

Some students require more time to learn a skill than others, but the time to practice a skill is limited by the shop schedule. For example, a student may be required to use a square, hand saw, hammer, screwdriver, and jack plane to build a small project. Even if the workmanship is of inferior quality, the student may be required to learn the use of other tools due to a time limit on the use of the saw, square, hammer, and plane.

The shop is open only a limited number of hours during the school day, so all work must be completed on schedule.

f. Neat Notebooks and Records - The theory usually precedes the laboratory work in the shop. The theory may include class discussions, classroom demonstrations, and tests, so it is necessary that shop information be recorded and filed in the student's notebook. Information from shop or project plans, bills of materials, and other general shop information is added to the notebook.

g. Use of Shop Supplies - There are rules governing the use of such items as nails, screws, bolts, welding rods, and other supplies that are managed by the shop program and made available for the students' use. For example, a student may underestimate the amount of nails needed to finish a project; therefore, he can buy them from the shop supply.

h. Use Good Housekeeping Practices - The shop must be kept clean, and the equipment and tools should be maintained in an orderly manner even when in use. Each student is required to participate in a good housekeeping program. A clean shop will have the following characteristics:

Clean floors
Tools in their proper places
Waste materials removed
Work benches clean of waste materials
Project materials in order
Shop supplies in order

i. Reporting System - Each student is responsible for reporting certain things dealing with the shop program. They are:

Tools and equipment that are damaged, broken, or not in condition to be used to produce good quality workmanship.

All fire hazards and other hazards endangering the student, such as oil on the floor, lack of ground wire on electric power equipment, and

accidents and injuries occurring in the shop.

Defective or missing protective equipment and devices (goggles, shields, and guards) for use when using the grinder, welder, and other power-operated equipment.

Lack of enough work to stay busy during the shop period.

4. Shop Grading Systems

a. Agricultural mechanics may be considered a subject in vocational agriculture that offers only practical work in the shop, but the theory must be learned before actually practicing the skill. Testing and grading for classroom work is considered very important in reporting a shop grade.

b. The agricultural mechanics shop is considered a very important laboratory for learning mechanical skills. Each student is graded on how well he performs the assigned shop skills, the type of workmanship he exhibits on his shop projects, and how closely he adheres to the shop rules and regulations.

References:

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, IL, 1967.

CONSTRUCTION AND MAINTENANCE

Unit A: Introduction

Topic 2: Shop Safety and Clean-Up

Suggested Procedure and Activities: Safety devices may be brought into the classroom and used as teaching aids during the discussion. Safety transparencies may also be used as a teaching aid. Demonstrations of safety practices by instructor and students will be effective teaching tools.

1. Importance of Safety Measures in Agricultural Mechanics

   a. In a recent year, the agriculture industry lead all other industries in the number of deaths and injuries caused by accidents. Agricultural machinery was the major source of the recorded accidents. There are about 2,000,000 disabling injuries each year in all the major industries, and about 290,000 of these are in the agriculture industry.

   b. Everyone hopes to live a life free of accidents and illness. Industry today wants safe and efficient employees. It wants employees who can advance in their work. If the employee receives a permanent injury, there may be a reduction in the earning power due to a skilled worker becoming an unskilled worker. The family standard of living may be lowered, and the injured employee may need to go through a retraining program. Many people endure this type of experience each year.

   c. When visiting a grain elevator, cotton gin, oil mill, fertilizer factory, oil refinery, textile mill, machinery repair shop, machine shop, paint factory, or feed mill, notice how signs and warning signals attract attention to danger areas. The signs may be in the form of color codes and the signals only a flashing light. Many of the danger zones have warnings for the benefit of the employee, because the employer realizes that accidents are a preventable waste.

2. Safety Goes Beyond the Use of Tools

   a. The student is usually not like the safe electrician who automatically keeps all tools in good condition, knows exactly how to install wires and fixtures without endangering himself and others, knows about the dangers of electricity, and has a complete knowledge of the field work. The electrician's entire education on the subject has caused him to develop a safe attitude. So, the electrician's education on the subject includes habits, skills, knowledge, and attitudes favorable to safe work.

b. The student must become safety conscious if he is to develop safety habits. If he knows that the way he is doing something is dangerous, he should stop and change to a safer way. An accident might be prevented.

c. If a student follows shop rules and regulations, there will be little or no danger of having a shop accident. One of the first requirements in an agricultural mechanics shop is to observe all shop safety rules. If the safety rules are not observed, accidents will happen. For example, a factory supervisor became lax and permitted his personnel to work without goggles; within one month eye injuries went up five percent. Rules are enforced to protect the student.

3. Laying Out and Arranging a Shop to Prevent Hazards

a. Location - Locate the shop building on a well drained site with adequate space around the building for a concrete apron and movement of equipment. The shop should be accessible to the center of operation (near the home) and have at least one large service door.

b. Size - The size of the shop will be determined by the size and type of equipment to be maintained, type of tools used, storage area needed for spare parts, and supply area needed. Draw a floor plan showing size of shop.

Transparencies Nos. 1 and 2

c. Arrangement - The shop area should be large enough that work benches, equipment, tool racks and cabinets, and bins can be arranged around the walls leaving space to work on machines. Show on drawing the arrangement leaving an uncluttered work area for machines to be serviced.

d. Equipment Arrangement - Locate each shop area on a floor plan sketch showing metal work, cabinets, and metal work supplies in one area; woodwork, cabinets, and woodwork supplies in another area; and storage bins and supplies in a third area.

e. Lighting - Shops should have adequate window space to furnish sufficient light during daylight hours. Skylight roofing can add light even with window lighting. All shops need overhead lights which must be used at night and some days when there is a lack of sunlight. Portable lights are also a necessity in a shop. They bring adequate light directly to the work and eliminate shadows when working in certain positions. Light painted walls will also help eliminate shadows by putting more light on the subject.

f. Wiring - All shops should have both 120- and 240-volt circuits. Motors that exceed ½ horsepower and welders require 240 volts. Install enough conveniently located outlets around the walls to reduce the use of an extension cord.

4. Shop Ventilation

Transparency No. 3

Most shops are constructed with enough doors and windows to provide adequate ventilation. However, weather conditions may control the use of these building openings during certain seasons of the year. Generally, the door and window area should equal about 25 percent of the floor space.

If doors, windows, and louvers cannot provide adequate ventilation, then artificial methods must be used to clean the area of fumes, smoke, dust, and certain chemicals that may contaminate the air.

a. The so-called artificial means of ventilating a shop are:

(1) Ventilating fan placed in wall of building forcing inside air outside of the building. Foul air is removed from the entire shop by this system.

(2) Hoods equipped with exhaust fans that force air through ducts to the outside. This is the most efficient system for removing foul air from a small work area. Both the ventilation fan and hood exhaust system must be able to pull in fresh air from a louver, door, or window in order to function properly.

(3) Tube exhaust venting systems which are used to remove exhaust fumes from an operating engine. The tube is placed over the exhaust pipe of a machine and it extends through the wall where the fumes pass to the outside. There is no fan in the tube, so the carbon monoxide gas is forced outside through pressure build up in the exhaust pipe.

Fans that circulate air within a shop area cause a small amount of air to be moved to the outside of the building. The main purpose of this type of fan is to cool. Ventilating fans also are used as cooling fans by pulling in fresh cool air and forcing out stale warm air. Another type of circulation that moves the air around in a given area is the heating unit fan. This type of unit affects ventilation only if doors or windows are open.

b. Areas that are considered important to ventilate are:

(1) Welding - Smoke and vapors are removed.

(2) Painting - Fumes are removed.

(3) Chemical Storage (Liquid and Dust) - Poisonous dusts and/or fumes are removed.

(4) Machine Maintenance and Repair - Carbon monoxide gas is removed.

Transparency No. 4

5. Using Color Schemes

In a small repair and maintenance shop color coding equipment and work areas is used mainly as a reminder of safety precautions to be observed by one or two people. Regardless of the number of people involved, it is a sound practice to use all safety measures possible to prevent an accident.

a. There are seven colors that are commonly used in a safety color dynamic program. They are:

(1) Red - This color indicates the location of equipment to extinguish fires. The fire equipment and the area where it is located should be painted red or painted with red bands.

(2) Orange - Orange means danger, especially moving parts on machines or equipment; therefore, power tool guards, pulleys, cutting edges, and the inside doors of fuse and switch boxes are painted orange to designate the location of dangerous parts.

(3) Yellow - The color yellow designates caution as applied to operating wheels, levers, and other controls. It is used to mark aisles, handrails, equipment location, and hazardous places that could result in a fall. It is also used to mark gear handles and levers on machines and equipment.

(4) Yellow and Black - Yellow and black strips can be used to mark raised entrance areas such as door sills, center posts in shop, barn, and sheds and corners of buildings next to traffic entrances.

(5) Green - The color light green is found on the body and base of power tools such as grinders, drill presses, and work benches. This color refers to the safer part of the machine or piece of equipment.

(6) Ivory - This color is used for tops and edges of benches, inside of cabinets, and nonmovable edges of power equipment. Buff or ivory adds to visibility of machines and equipment. It also adds to the effectiveness of other colors.

(7) Green - Safety green is a color to mark first-aid kits and cabinets for quick location. A green cross painted above the kit or on the cabinet is still more effective than the kit being painted. This green color should not be confused with the high-visibility light green color.

b. The uses of paint and vinyl is as follows:

(1) Paint - Quick-drying synthetic resin base exterior enamel paints are used to paint the different colors on the machines and equipment. If yellow and black stripes are painted, use either yellow or black to paint a solid color strip. After it dries, use gummed masking tape in strips at an angle on the solid painted strip and apply the other color paint (yellow or black).

(2) Vinyl - If the floor area is identified, vinyl yellow strip, yellow and black strips, or yellow discs may be used.

Transparencies Nos. 5 and 6

6. Shop Safety Reminders

a. Good Housekeeping - A clean shop is usually a safe shop. Some examples of good housekeeping are:

Shop work benches are clean.

Shop floor is clean.

Fire hazards (wastes such as sawdust, old rags, and shavings) are removed from the shop.

Materials and supplies are restored to their proper place.

Tools are kept in their proper place.

Some examples of poor housekeeping include:

Cluttered work areas.

Dirty, wet, greasy floors.

Tools lying around the shop.

Materials protruding into open walkways.

Loose objects and materials of various kinds on the floor.

b. Use of Protective Devices - Eye protection is inexpensive, and good eyesight is priceless. Some injuries may be as slight as a scratch; yet, others may be permanent. Safety devices and their uses include:

Goggles - When welding, grinding, drilling, or chipping certain objects, using a wire brush, and handling certain chemicals, goggles should be worn.

Protective Clothing - Clothing should be free of flammable materials, pockets, and ragged ends when welding. Also, the sleeves and collar should be buttoned. High-topped shoes may eliminate burns from slag or sparks created by the welder. Loose clothing, shirt tails out of trousers, long sleeves, and ties are shop hazards when using power tools.

Gloves - Hand pads or gloves are necessary when handling sharp, heavy, hot, or rough materials around a shop. When welding, fire resistant gauntlet gloves must be used to protect the hands and wrists from burns.

Welding Helmet - A welding helmet is absolutely necessary for protecting the eyes and face from arc rays and splattering hot metal particles.

Respirator - Respirators are used to protect the student from inhaling paints and their ingredients when spray-painting.

c. Behavior in the Shop - Shop workmanlike manners should be practiced at all times. Some bad behavior practices are:

Scuffling	Pushing
Wrestling	Tripping
Giving the "hot foot"	Loud talking
Being idle	Hurrying on project
Running	Playing with tools
Talking to classmates	Disobeying other shop rules

One reckless student can make the entire shop unsafe. The reckless shop student should be considered in the same light as a reckless driver; that is, he is failing to consider his safety and the safety of his fellow students. Good citizenship is regarded very highly in the shop.

d. Handling and Placing Materials Used in the Shop - There are several methods the student can use to properly handle and place materials in the shop.

Heavy objects in farm machinery work should be handled by blocks or block and tackle, suspended from an A-frame or other well-supported structure.

To lift a heavy object by hand, a student should use the following procedure:

Lift with the legs to avoid back and abdominal injuries.

The feet should be kept apart, knees bent, and the back straight as the load is lifted with the legs.

The load is lowered to the floor using the same method as when lifting except that the knees are bent downward.

While carrying a load, the hands and body should not be shifted to another position.

If the load is heavy, ask for help.

Rough materials and metal should be handled with gloves.

Materials should be stacked in a place that is a safe distance from aisles, working areas, and entrances. The materials should be stacked in such a way that they will not slip, crush, or fall. Materials should be handled in such a way that the pieces or parts will not strike anyone in the working area. More than 25 percent of all disabilities are caused by the improper handling of materials.

e. A ladder is a very important piece of shop equipment. Ladder safety depends upon how and where the ladder is used. A makeshift box or crate should not be used in place of a ladder to inspect machinery, replace ceiling light bulbs, paint walls, hand fixtures, or work on anything above one's reach. The following ladder safety measures should be observed:

Check the ladder for missing cleats.

Check the ladder rungs for cracks and weaknesses.

Check the ladder for broken spreaders.

The base of a straight ladder should be about one-fourth its length from the wall.

A folding step ladder should be opened and locked open.

Use both hands when climbing a ladder, and do not reach for an object too far away when on a ladder.

Transparencies Nos. 7 and 8

7. Precautions to Observe

a. Hand Tools - Over one-fourth of all shop injuries are caused by the use of hand tools. The injuries stem from three principal causes:

Improper use of the tool
Using the wrong tool for the job
Using defective tools

b. Precautions to Observe When Using Hand Tools - These precautions are:

A dull tool may slide or stick to the material causing an injury; therefore, cutting tools should be kept sharp.

Tools with mushroom heads (cold chisel with spreading head) are dangerous. A chip may break off and strike any part of the body. Splintered, broken, or loose tool handles can also cause flying objects.

A screwdriver is not to be used as a cold chisel, pry bar, paint paddle, putty knife, or punch. Each tool is made for a specific job or jobs, and if the job is to be done safely and quickly, the proper tool should be used. Use the proper sized tool for the job.

No tool should be allowed to lie around. Tools should remain in their proper places when not in use, and the sharp edges of cutting tools should be protected. Sharp edged tools are dangerous if placed in improper locations.

Tools are never to be carried in the pocket. Sharp or pointed tools are very dangerous in any pocket on the body. A tool box or tool kit and belt tool holders are safe carriers.

Badly worn tools are dangerous, especially pliers and wrenches with jaws. Using a hammer to strike a handle or extended handle to gain more pressure is not a safe practice. Improper sized wrenches may slip on bolt nuts and cause injury to the knuckles. Adjust the jaws of adjustable wrenches so they will not slip.

Greasy or dirty tools are difficult to handle properly. Clean tools make the work more efficient. Tools should be cleaned before they are put on the tool rack.

All work should be held steadily and the cuts made away from the body except when using a draw knife. If vises are used to hold the work stocks, they must be mounted securely.

Tools that have tang handles should be provided with a slip over the handle to protect the hand. For example, a file is dangerous if used without a handle to cover the tang.

c. Precautions to Observe When Using Jacks and Hoists

(1) Jacks, like many other tools, are considered safe if used properly and unsafe if not used according to recommendations. Observe the following when using jacks:

Check the jack's rated capacity and use accordingly. Do not use to lift overloads. An overloaded jack that fails is very dangerous.

Use the operator's manual to determine points of lubrication, and lubricate as recommended. Also check the hydraulic fluid in the hydraulic type jack, and fill with recommended jack oil.

Position the jack so that the lift shaft will be vertical to the ground or floor. The place the jack lift touches the machine should be strong

enough to carry the weight, flat and level.

When working from the ground, use a heavy block under the jack. Do not use extenders between the jack and machine. One large solid block is safer than several small blocks.

Before lifting a machine with a jack, stabilize it. Set the brakes and place the transmission in gear or in park. One wheel touching the surface should be blocked. Equipment can be stabilized by hooking it to the tractor.

After lifting the machine off the surface and it begins to shift, lower the machine, reset the jack, and reblock the machine. Check to determine whether or not the jack saddle is sliding on the frame.

Jack handles can be dangerous if not held firmly. Stand to one side of the handle while holding and releasing it. Remove the handle from the jack as soon as the machine is raised to the proper height.

After the machine or equipment is raised to the proper height, support it with blocks or stands. This should be done immediately after reaching the proper height. Most support stands are converted to a rigid stand by using a lock pin.

(2) Hoists, like jacks, can cause serious accidents. The improper use of both can result in crushing injuries to the individual. Most hoist accidents are caused from slipping chains and overloading. To use hoist equipment safely:

Check the chains for extreme wear, bent links, and cracks. Damaged links can be replaced with new links, but if the entire chain is worn it should be replaced. A severely worn or damaged chain may be repaired by the manufacturer.

Check the hoist hooks for damage. A cracked, bent, or sprung hook should be replaced. If in doubt about the condition of a hook, compare it with a new one before replacing it.

Use the hoist according to capacity recommendations. Do not exceed the load the hoist should lift. Consider the A-frame load when using a hoist. It must be strong enough to withstand the lifting and hold the desired load.

Attach the hoist at the proper place on the A-frame. Some frames are made only for a center hook up and will not withstand a sideways pull.

Have the machine or implement centered so that it will balance under the frame. It may be possible to tip the A-frame if the machine or equipment is not directly under the frame beam.

Stand at a safe distance from the machine or implement being lifted. Keep hands away from areas that may cause injury. Pay careful attention to the object being lifted as it leaves the ground or floor. Place the machine or implement on blocks or stands immediately after lifting.

Transparency No. 9

d. Precautions to observe when using portable electric power hand tools include:

Check the tool before using. The three-prong plug (one of the prongs is for grounding the tool) should be free of damage.

Keep the cord out of the aisles or other traveled areas and protect it from hot or rough surfaces, oils, and chemicals.

Electric hand tools should not be used around flammable vapors or gases; a spark can cause an explosion.

The hands should be dry when using a power tool. Dry hands may reduce the shock effect if there is an improper ground or short in the tool.

Always remove the cord and plug from the outlet by grasping the plug instead of grasping the cord.

The tool should remain on a shelf or rack when not in use. The cord should be rolled loosely when storing the tool.

NOTE: Hand power tools should be used by experienced students, those that have been instructed in safe methods of using them.

e. Precautions to observe while working with electricity or electrical equipment include:

Locate and check the use of the master and other switches in the shop.

All electrical tools should be checked for damaged parts, plugs, cords, and grounding prongs or wires before using on any job. Sparking or smoking of a motor is a signal to disconnect the equipment and report the condition.

Extension cords should be of adequate size to handle the electrical load. Exposed wires, faulty plugs, and worn insulation are danger signs on extension cords. They should not be placed in aisles or pulled over sharp

edges. Cords should be protected from damage by the power tool. They should be disconnected by pulling the plug from the outlet.

Electric portable tools should not be used on damp floors or with wet hands. Rubber-soled shoes are the safest shoes to wear when handling electrical equipment.

When fuses blow, there is an indication of an overload or a short. A supply of proper sized fuses should be kept on hand.

When cleaning electrical tools, the proper solvent should be used. Gasoline is very flammable and should not be used.

NOTE: An electrician considers all wires as live wires until proven to be different. Bare fingers are not used to check whether a circuit is energized or not. The control switch is locked open if work is required on the circuit.

When working with electricity, the following steps should be observed:

Splices should be soldered and taped.

Screws should be tightened firmly, connecting the wire to the fixture.

Proper sized wire should be used. Follow the rules of the National Electrical Code to determine the wire size.

Transparency No. 10

f. Precautions to observe concerning special shop hazards include:

Chemicals (acids and caustics) should be used under the direct supervision of someone who is acquainted with their proper use and dangers.

Compressed air is very dangerous, and it should be used with caution when painting and cleaning clothing and equipment. It should never be used under the following conditions:

Pointing nozzle at the body as a prank; it can damage the eyes and ears very easily.

Kinking the line to cut off the air or reduce the air flow through the hose.

Cleaning the equipment where metal waste is located, without protecting the eyes.

When the pressure is too high for the job being done.

To remove liquid from surfaces.

8. Student Responsibilities

Each student is responsible for reporting certain things dealing with the shop program, especially when they are related to shop safety. Some things that should be reported are:

Tools and equipment that are damaged, broken, or not in condition to be used to produce good quality workmanship.

All fire hazards and other hazards endangering the student, such as oil on the floor, lack of ground wire on electric power equipment, and accidents and injuries occurring in the shop.

Defective or missing protective equipment and devices (goggles, shields, and guards) for use when using the grinder, welder, and other power-operated quipment.

Lack of enough work to stay busy during the shop period.

9. First Aid in Agricultural Mechanics

a. Minor injuries, such as cuts, bruises, scratches, burns, or punctures, should be treated immediately. The shop first-aid kit may be a handy device to treat minor injuries. In many cases, the school nurse is called to assist with injury treatments. The student should report injuries to the instructor.

b. Major injuries, such as severe shock, scalds, burns, cuts, and broken bones, should be handled immediately by qualified school personnel and a physician. First-aid is administered before the student is sent to the hospital only if advised by the instructor; otherwise, the placing of splints, applying of tourniquets, or administering artificial respiration should not be a general practice by the student.

10. Safety Inspection Checklist for Vocational Agriculture

A safe environment is essential for students and teachers of vocational agriculture. Safety inspections of the total vocational agriculture department should be made on a regular basis. Unsafe conditions should be corrected as soon as possible in accordance with accepted local procedures. Administrators, teachers, and students can be used as a committee to make safety inspections. The following statements are to be used as a suggested check list for safety inspection: (indicate satisfactory or unsatisfactory by each)

a. Instruction (classroom and laboratory)

(1) Safety instruction is an integral part of each teaching unit.

(2) Accident prevention is taught with a positive approach.

(3) The proper use of each piece of equipment is demonstrated before student use is permitted.

(4) Informational safety rules are posted near each hazardous piece of equipment.

(5) Printed general safe practices are provided each student.

(6) Instruction is provided on proper methods of lifting, carrying, and lowering heavy objects.

(7) Safety posters are used and changed frequently.

(8) Each class has a safety inspector or committee and each student has an opportunity to serve on the safety committee some time during the four years.

(9) A procedure is established for students to recognize and report hazards.

(10) Tests on safety are given regularly as a part of the testing program.

(11) A complete record is kept of safety instruction, including test records, and are on file.

(12) First aid instruction is provided all students.

(13) Students are taught types of fire extinguishers and how to use them.

(14) Running, horseplay, etc., is completely prohibited.

b. Personal Protection

(1) Goggles or protective shields are provided and required for all work where eye hazards exist (grinding, drilling, wire brushing, etc.).

(2) Shields and goggles are provided for electric welding and acetylene - welding.

(3) Respirators are provided for dusty or toxic atmospheric conditions, such as spray painting.

(4) Coveralls or other appropriate apparel are worn and checked (for loose ends) when working in the shop.

(5) Sleeves are rolled above elbows and ties are removed when working around machinery.

(6) Jewelry (rings, wristwatches, etc.) are not worn when working around machinery.

(7) An adequately stocked first aid cabinet is provided in the agricultural mechanics shop and laboratory and checked monthly.

(8) The shop is kept locked when the instructor is not present.

c. Accident Records

(1) All accidents are reported to the instructor.

(2) Accident reports are completed on all accidents, regardless of nature or severity, and reported to the school nurse or principal's office.

(3) Accident reports are analyzed for instructional purposes and for aiding in the prevention of other accidents.

(4) Written posted policies are maintained outlining correct procedures in case of accident.

d. Classroom and Laboratory

(1) Equipment and supplies are kept arranged with adequate aisles for safety and easy exit.

(2) All compounds and materials are properly labeled.

(3) Poisonous materials are labeled and kept separate from other materials.

(4) Proper laboratory procedures are demonstrated before students begin work.

(5) The laboratory is adequately ventilated.

(6) Fire resistant materials are used where needed.

e. Agricultural Mechanics Shop

(1) The shop lighting is safe, sufficient, and well placed.

(2) Ventilation is adequate to remove all fumes.

(3) Floors and aisles are skid resistant.

(4) The shop has two or more well marked exits.

(5) Students are familiar with emergency procedures in evacuating the shop.

(6) All hinged doors open outward and are kept unlocked during shop periods.

(7) Walls and storage areas are kept clear of objects that might fall.

(8) Adequate storage space is provided.

(9) Lockers and storage cabinets are regularly inspected for cleanliness and fire hazards.

(10) CO_2 fire extinguishers are available for electrical fires.

(11) Dry powder extinguishers are available for gasoline and oil fires.

f. Housekeeping

(1) The general appearance of the shop is that of orderliness.

(2) All tools and materials are properly stored when not in use.

(3) Lumber and metal are properly stacked.

(4) Work benches are kept clear of unneeded materials.

(5) The shop floor is kept clear and free of water, oil, and foreign materials.

(6) Provision is made for daily removal of sawdust and other waste materials, or it is stored in fire-proof, approved containers.

(7) Approved properly marked containers are provided for scraps.

(8) Scrap materials are placed in proper bins promptly.

(9) A spring-lid metal container is provided for oily waste and rags.

(10) Storage of supplies and shop projects is arranged safely.

(11) The tool and supply room is maintained in an orderly and safe condition.

(12) Flammable materials are stored in metal cabinets.

(13) Dangerous materials such as gasoline are stored in approved containers in a separate place.

(14) Flammable materials are not used for cleaning purposes.

(15) Washing facilities are kept clean and neat.

g. Hand and Power Tools

(1) Special tool racks are provided and kept in an orderly condition.

(2) Hand tools are kept sharp, clean, and in safe condition.

(3) Students are trained and use the proper size tool for the job to be done.

(4) Tool handles are kept firmly fastened and free from dirt, oil, and grease.

(5) All hand tools are regularly checked for defects and damage.

(6) Machines are arranged so that workers are protected from hazards of other machines, passing students, etc.

(7) All gears, moving belts, etc., are protected by permanent enclosure guards.

(8) All machines have proper guards at point of operation.

(9) All power tools are operated according to manufacturers' directions.

(10) A student is permitted to operate a machine only after demonstrating his ability.

(11) Danger zones are properly indicated and marked.

(12) Permanently placed machines are securely fastened to the floor or bench.

(13) Strict supervision is provided students using hazardous equipment.

(14) Machines are always shut off when not attended.

(15) Brushes are used in cleaning equipment.

(16) Unsafe equipment is promptly repaired or put out of use.

(17) Grinder wheels are kept in balance. 87

(18) The grinder tool rest is maintained within 1/8 inch of wheel.

(19) Pusher sticks are available and used on circular saws and jointers.

(20) All equipment is color coded.

(21) There is adequate lighting for safe work at each equipment area.

(22) All work is securely fastened when drilling.

h. Electrical Safety

(1) All electrical control switches are within easy reach of the operator.

(2) All motors, fuse and switch boxes, and other electrical equipment are grounded.

(3) There is a master control switch for all electrical installations.

(4) All switches are enclosed.

(5) Electrical outlets and circuits are properly identified.

(6) All extension cords are in safe condition and are not carrying excessive loads.

(7) Equipment is provided with overload and underload controls.

(8) Electrical motors are wired to comply with the National Electrical Code.

(9) All convenience outlets are grounded.

(10) All machines and power tools are properly grounded.

i. The School and Land Laboratory

(1) Machinery and equipment are kept in proper working order.

(2) The operator is familiar with the operation manual of the machine being used.

(3) Power take-off drives on machines are shielded at all times.

(4) Machines are turned off when being adjusted, repaired, or serviced.

(5) Machines are used only for the jobs for which they are made.

(6) Extra care is taken in hitching and unhitching.

(7) Farm equipment used on the highway is properly identified with a "slow moving vehicle" emblem.

(8) Stairs and walks are well lighted and clear of obstruction.

(9) Ladders are in good condition and tested before use.

(10) An appropriate fire extinguisher is available in each farm building.

(11) All heating and electrical equipment is shielded and grounded.

(12) All engines are stopped w' en refueling.

(13) An adequate water supply is available for controlling fires.

(14) Fire-fighting equipment is readily available and well marked.

(15) "No Smoking" signs are placed in strategic places.

(16) Maximum vision is provided where farm driveways enter the highway.

(17) All machines and equipment have proper lights for night travel.

(18) Stocks or other safety devices are used when treating or caring for farm animals.

(19) Insecticides and other drugs are properly identified and stored.

(20) Newly stored hay and grain are regularly checked for heating.

(21) Dated medicines are destroyed.

j. Field Trips and Farm Visits

(1) Rules and laws of the highway are observed at all times.

(2) Only approved vehicles are used for farm visits and field trips.

(3) All vehicles are checked periodically to keep them in safe operating condition.

(4) Hazardous areas such as school zones, hill crests, etc., are given special consideration.

(5) The rights of pedestrians are respected at all times.

(6) When walking near highways, everyone faces on-coming traffic.

(7) Vehicles are not overloaded with either passengers or materials.

(8) All drivers and passengers are insured for both liability and personal injury.

(9) Proper signals are given for turns and stops.

k. Other

(1)

(2)

(3)

(4)

(5)

References :

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967.

2. Wakeman, T. J., Modern Agricultural Mechanics , The Interstate Printers and Publishers, Inc., Danville, Illinois, 1977.

3. "Facility Standards and Equipment for Agricultural Education Programs", Texas Education Agency, Austin, Texas, 1974.

4. "Fundamentals of Machine Operation, Agricultural Machinery Safety", Deere and Company, Moline, Illinois, 1974.

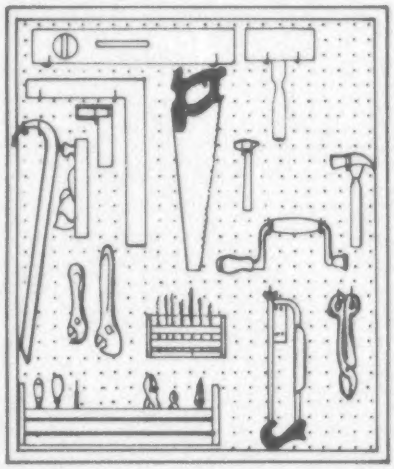
5. "National Standard Safety Inspection Check List for Vocational Agriculture", Joint Safety Committee of the American Vocational Association - National Safety Council.

6. "Safety in the Agricultural Mechanics Shop", University of Illinois, Urbana, Illinois, 1969.

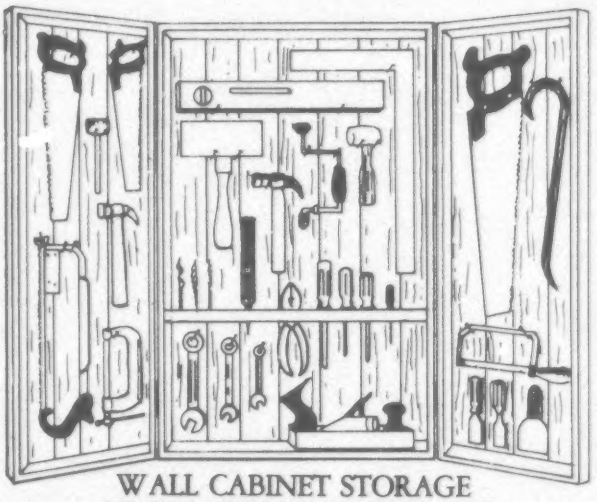
7. "Shop Safety", V. A. I. Student Material, Vocational Instructional Services, Texas A&M University, College Station, Texas.

8. "Shop Planning, Basic Design of Shops and Service Centers", American Association for Vocational Instructional Materials, Athens, Georgia, 1975.

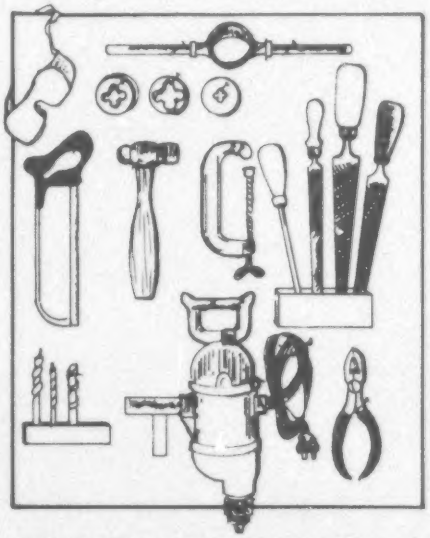
STORING HAND TOOLS



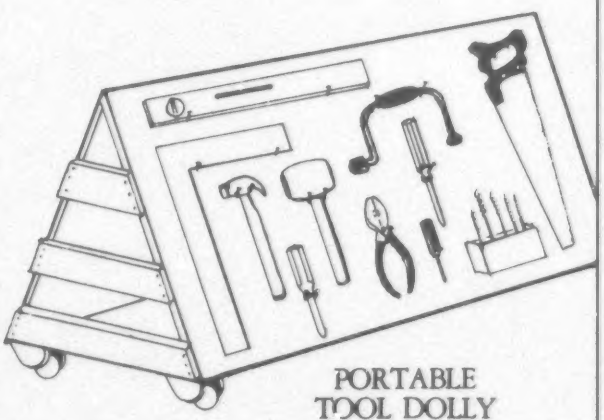
OPEN WALL STORAGE OF WOODWORKING TOOLS ON PEGBOARD



WALL CABINET STORAGE OF WOODWORKING TOOLS

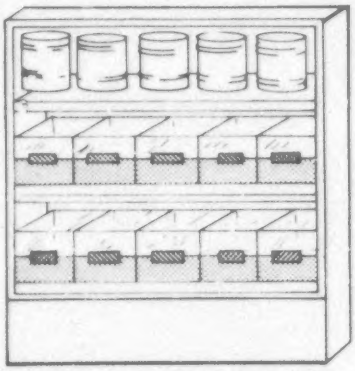


OPEN WALLBOARD STORAGE OF METALWORKING TOOLS

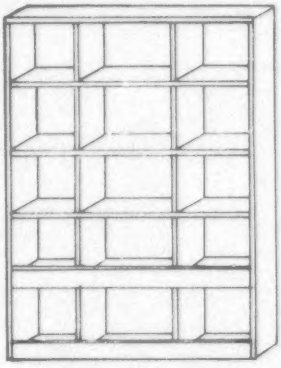


PORTABLE TOOL DOLLY

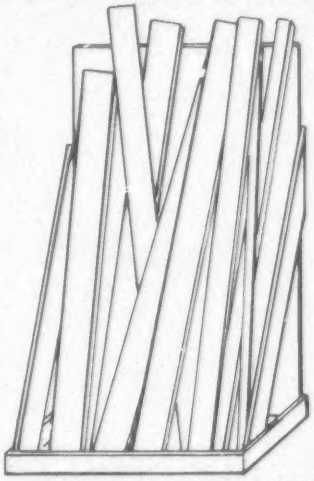
MISCELLANEOUS STORAGE



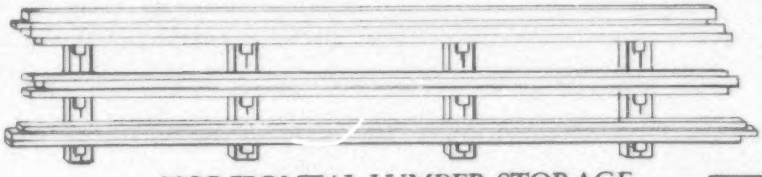
BOLTS, NUTS, SCREWS & NAILS STORAGE



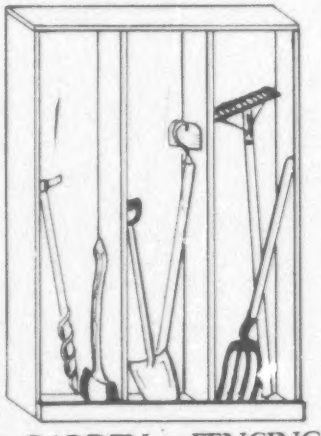
PARTS STORAGE



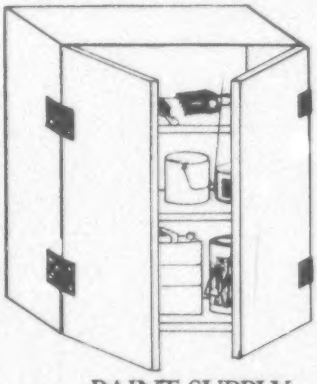
VERTICAL LUMBER STORAGE



HORIZONTAL LUMBER STORAGE



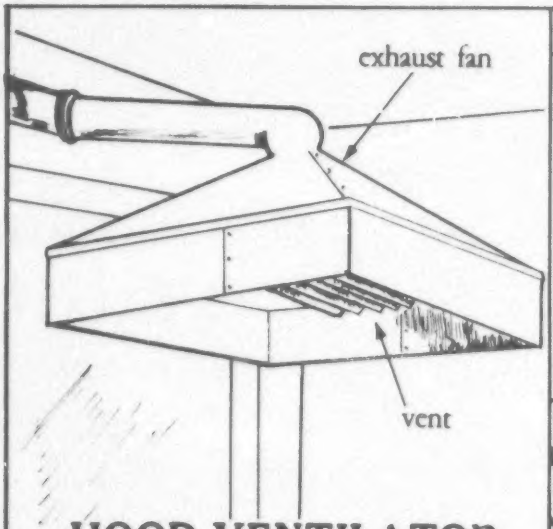
GARDEN & FENCING TOOL STORAGE



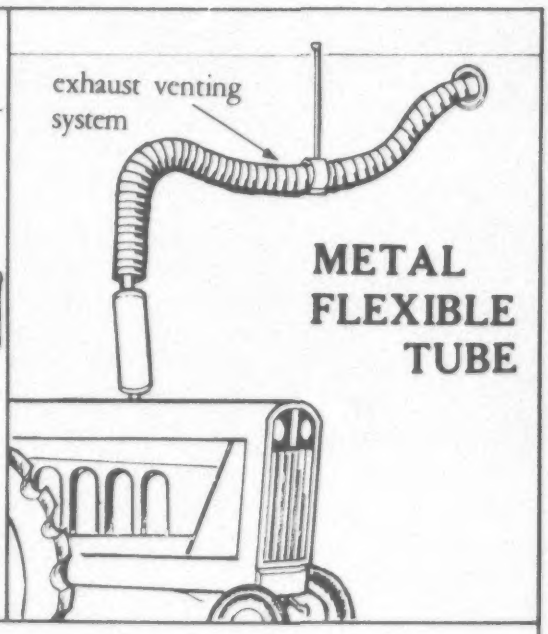
PAINT SUPPLY STORAGE

VERTICAL METAL STORAGE

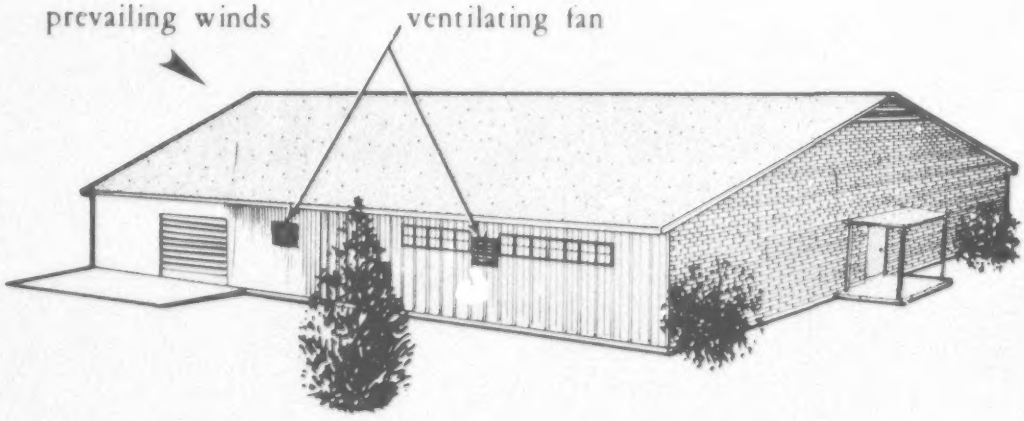
VENTILATION EQUIPMENT



HOOD VENTILATOR WITH EXHAUST FAN



METAL FLEXIBLE TUBE



EXHAUST FAN

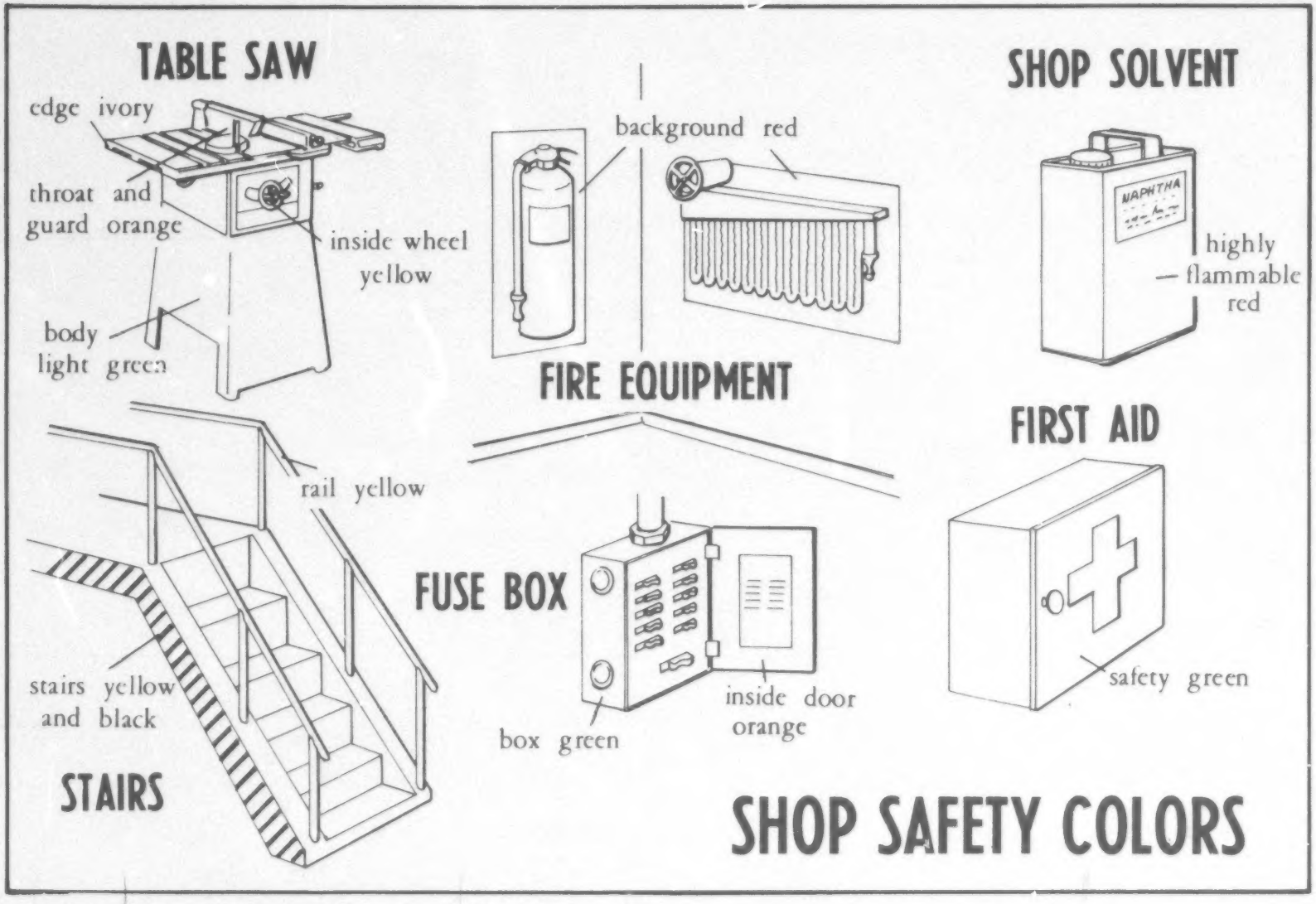
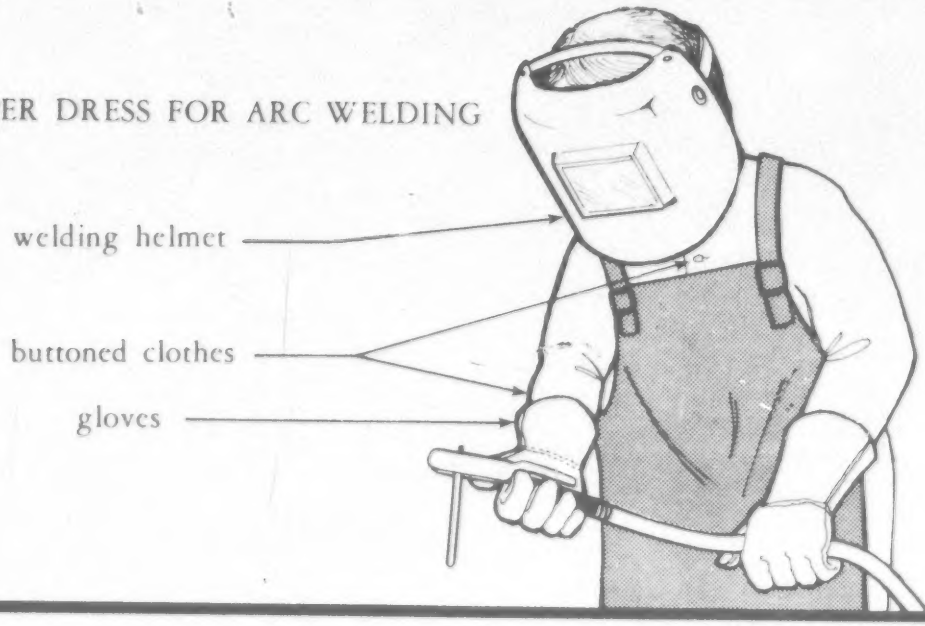


TABLE SAW
edge ivory
throat and guard orange
inside wheel yellow
body light green
FIRE EQUIPMENT
background red
SHOP SOLVENT
NAPHTHA
highly flammable red
FIRST AID
safety green
rail yellow
stairs yellow and black
STAIRS
FUSE BOX
box green
inside door orange
SHOP SAFETY COLORS

SHOP SAFETY

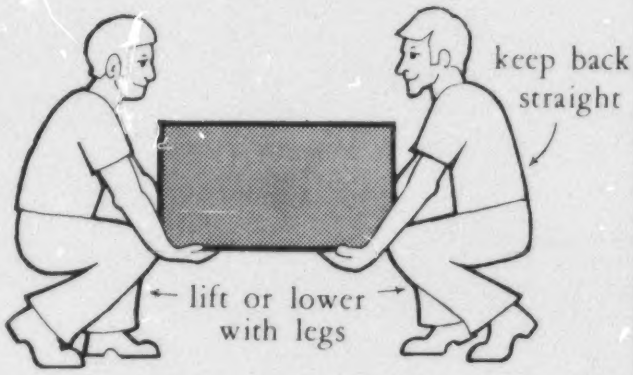
USE PROTECTIVE GOGGLES

PROPER DRESS FOR ARC WELDING

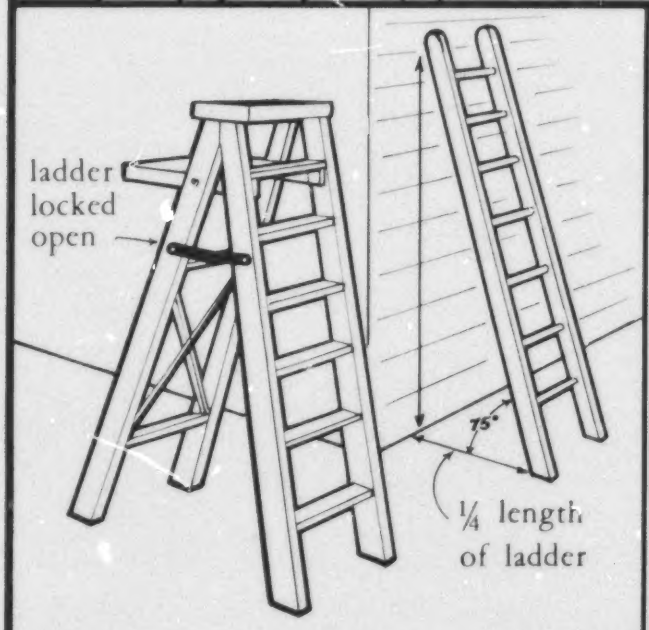


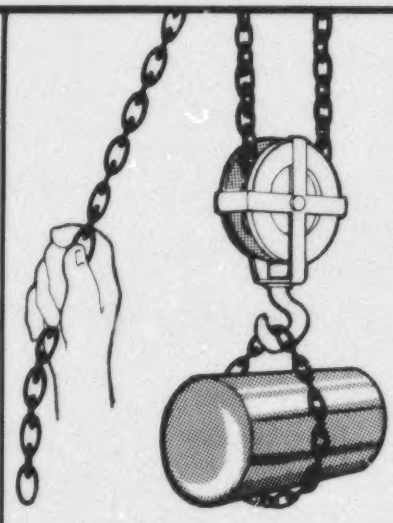
SHOP SAFETY

GET HELP TO HANDLE HEAVY OBJECTS



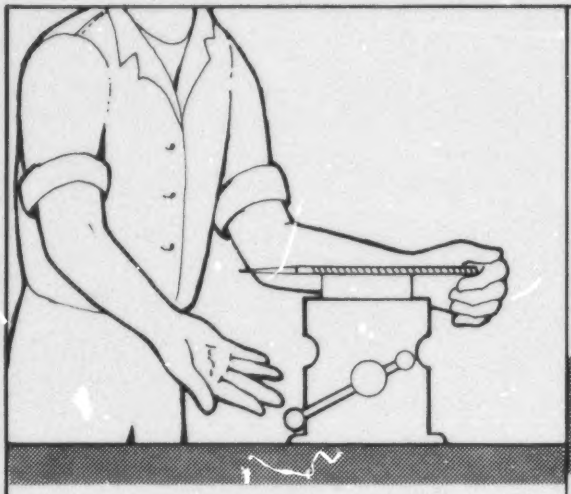
IMPROPER BEHAVIOR CAN BE DANGEROUS



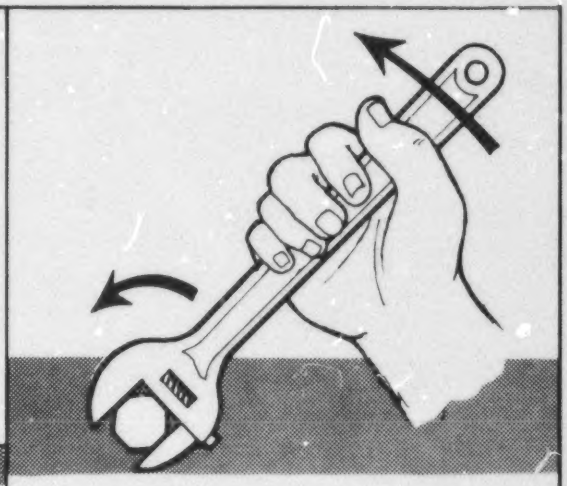


SAFE METHOD OF MOVING HEAVY OBJECTS

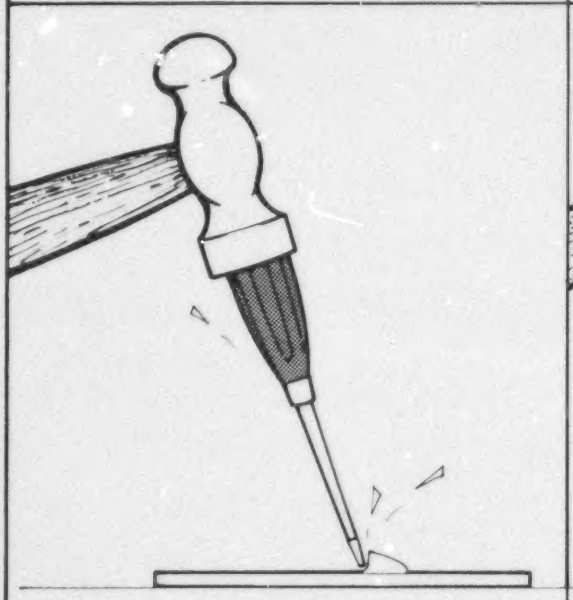
SHOP SAFETY-HAND TOOLS

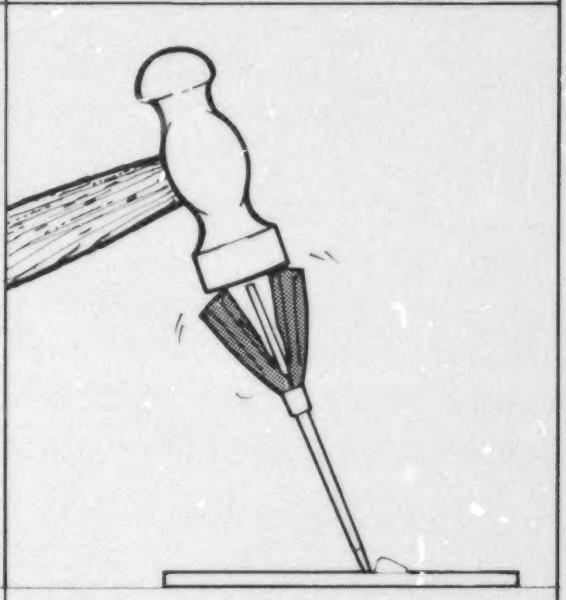


FILES WITHOUT HANDLES
CAUSE INJURY



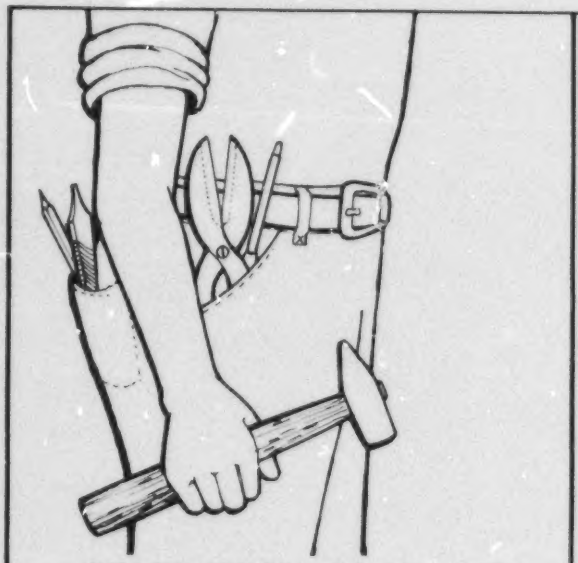
IMPROPER USE OF WRENCH
CAN CAUSE INJURY



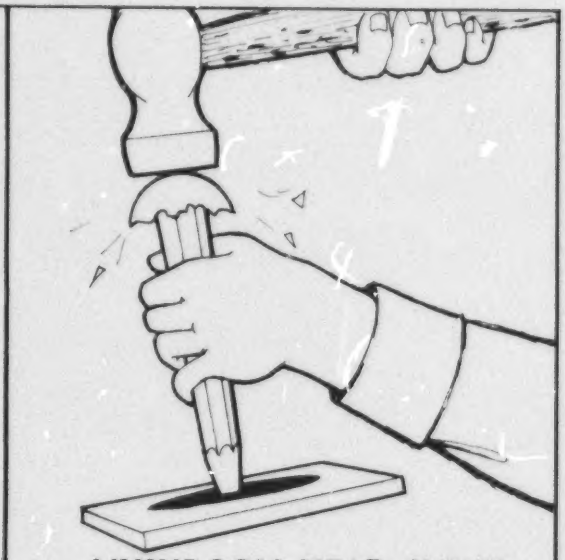


TOOL USE

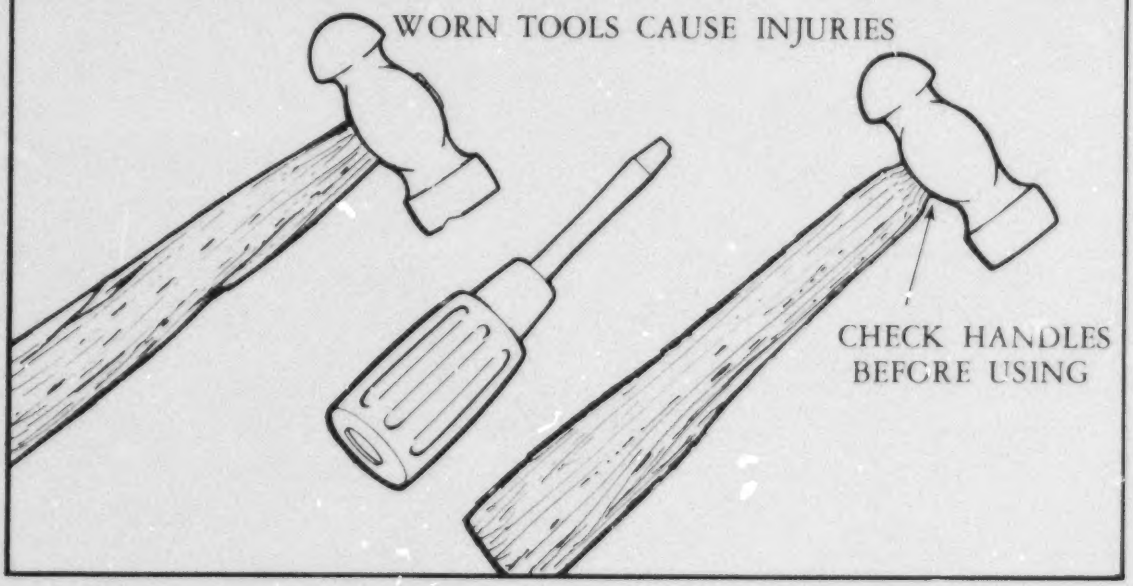
SHOP SAFETY-HAND TOOLS



SHARP TOOLS IN POCKETS
ARE DANGEROUS

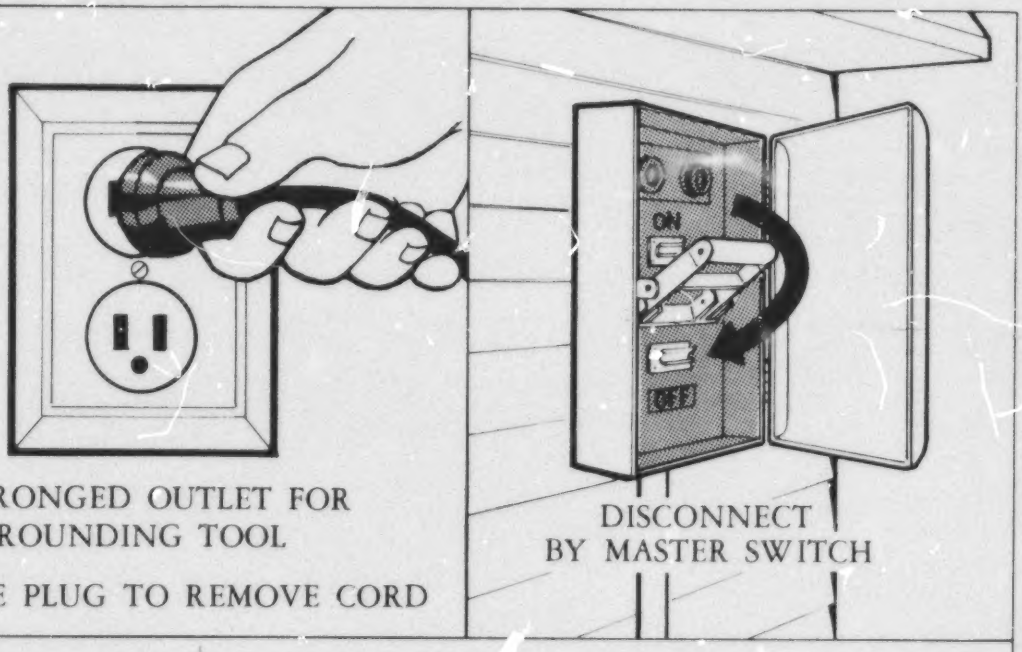


MUSHROOM HEAD SLIVER
CAN CAUSE INJURY



TOOL CARE

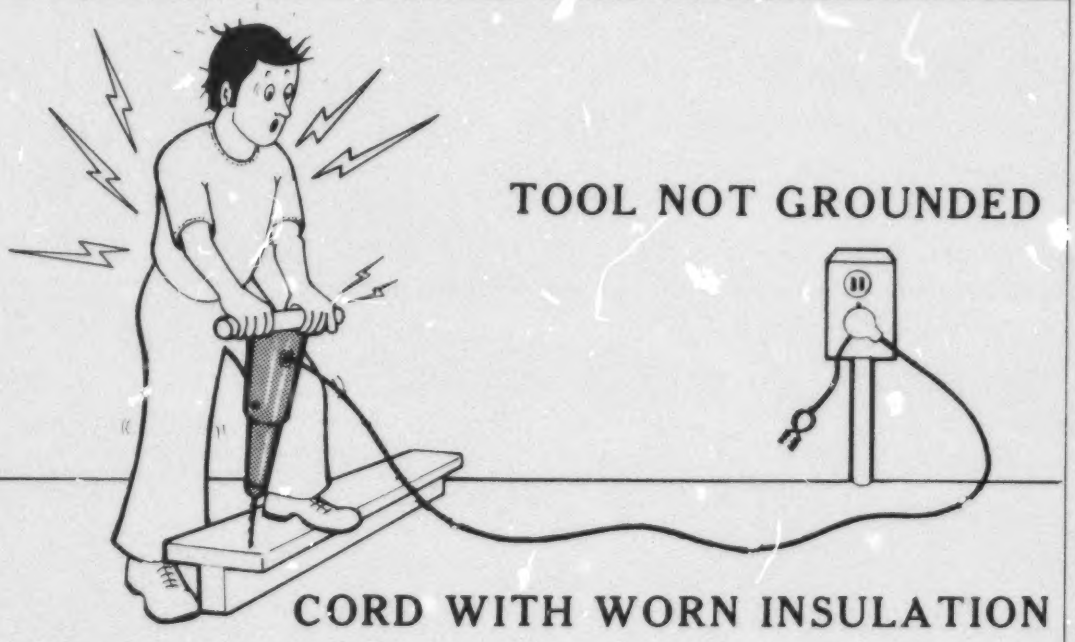
SHOP SAFETY



3-PRONGED OUTLET FOR GROUNDING TOOL

USE PLUG TO REMOVE CORD

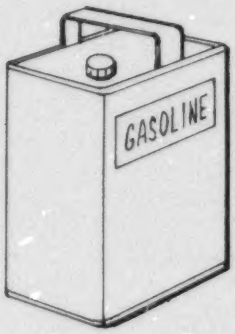
DISCONNECT BY MASTER SWITCH



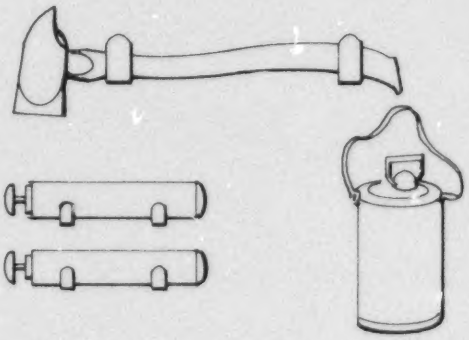
TOOL NOT GROUNDED

CORD WITH WORN INSULATION

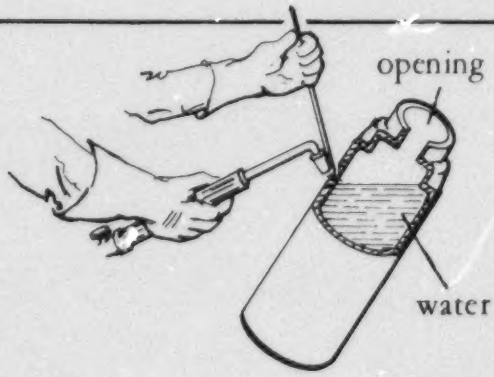
SHOP SAFETY (fire and explosions)



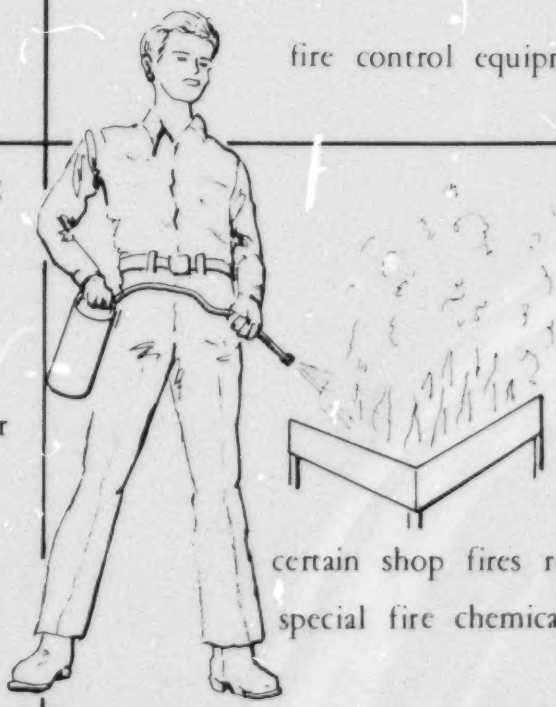
gasoline is not a safe solvent



fire control equipment



proper safety practice for welding and cutting containers



certain shop fires require special fire chemicals

CONSTRUCTION AND MAINTENANCE

Unit A: Introduction

Topic 3: Identification and Use of Hand Tools

Suggested Procedures and Activities: During the class discussion, the instructor should demonstrate the types and uses of each tool. Transparencies used along with the actual tool will serve as excellent teaching aids.

1. Introduction

a. Proper care of hand tools is important. The following suggestions are basic in tool care: tools should be kept properly conditioned and sharp; the cutting edge of tools should be protected when carrying or in storage; tools should be kept dry and lightly oiled when not in use; tools should be systematically returned to storage cabinets or the tool room following use; and use tools only for their designed purpose.

b. Safe use of hand tools is also important. The following suggestions are basic to hand tool safety: select the right tool for the job; dull or broken tools should not be used; tool handles should be in good condition and securely fastened; avoid dropping or throwing tools; fingers should be kept away from tool edges; and hand work should be done away from the body.

Transparencies Nos. 1 and 2

2. Selecting and Using Hammers

a. Common types of hammers are: ripping claw, curved claw, machinist's riveting, blacksmith's, engineer's, ball peen, soft face, and sledge.

b. Hammers are selected according to size, use, face, and handle type.

Transparency No. 3

c. When using a hammer, grasp the handle firmly near the end and strike the surface or nail squarely with the face of the hammer. This will prevent damage to both the hammer and stock. Care should also be taken when driving, pulling, and setting nails.

(1) Driving Nails - The following steps should be observed when driving nails:

The hammer handle should be grasped near the end. Check the face to see that it is clean, and check the handle for splinters and inset in the head.

Place the face of the hammer on the nail, then strike it with a light blow to start the nail. The nail should be held by the thumb and fingers near the nail head.

Deliver the remaining blows by putting the shoulder, elbow, and wrist into the action and striking the nail squarely on the head to prevent bending it and marring the wood.

The last blow or two should be lighter than the power blows in the center of the operation. This may prevent or eliminate hammer marks at the nail head.

(2) Pulling Nails - The steps in pulling nails include:

Nails are pulled without damage to the hammer and the board by first slipping the claws under the nail head and raising the hammer handle until it is vertical.

Slip a block of wood under the head of the hammer while it is in the vertical position and continue pulling the nail unless there is too much strain on the handle.

It is better to pull a bent nail, caused by driving, and drive a new one in a new place.

If pulling the nail requires putting too much pressure on the hammer handle, a wrecking bar should be used instead.

(3) Setting Nails - If casing, finish, or flooring nails are used it may be necessary to set the heads below the surface 1/16 of an inch by using a nail set. The set is braced by the lower fingers and tapped lightly with the hammer. Nail sets range in size from 1/32" to 4/32" at the tip or point.

d. Using the wrecking bar

(1) The most common ripping or wrecking bar is 24 inches in length. It has a gooseneck for pulling nails and a wedge-shaped, slightly bent end for prying loose boards. They can be found in sizes from one to three feet in length. Most wrecking bars are made of 3/4 inch octagon-shaped tempered steel.

(2) A wrecking bar is necessary for pulling large nails, wrecking buildings, opening wood crates, and dismantling many kinds of wood structures. A block of wood should be used under the gooseneck or the other end of the bar to protect the board from being marred. The wrecking bar is a protector of hammer handles, and it should be used if there is any doubt that too much strain is placed upon the handle. The wrecking bar

is not a crow bar; therefore, it cannot be used to pry stones, timbers, or machinery.

3. Selecting and Using Hand Planes

a. The hand plane is considered a paring or shaving tool for smoothing board surfaces either on the face, end, or edge. Surfaces may be smoothed or straightened in order to join boards by gluing. Planing can eliminate twists or crowns or correct the dimensions of lumber.

Transparency No. 4

b. Types of hand planes

(1) Jack Plane - This plane is the most commonly used for the many types of hand planes. It is from 11-1/2 to 15 inches long and is used mainly for smoothing large surfaces, and straightening board edges. The most commonly used jack plane is 14 inches long with a 2 inch wide cutter or blade.

(2) Smoothing Plane - A smoothing plane is from 5-1/2 to 10 inches in length. It is used mainly for smoothing, surfacing, and finishing work. It can also be used to work end grain on boards. A plane with a 1-3/4 inch wide blade, 8 inches long is considered standard.

(3) Block Plane - This plane is used for cutting end grain or working small pieces of materials. The average length of this plane is about 6 inches.

(4) The Fore and Jointer Planes - These planes are used for straightening the edges of long pieces of material or wood objects. The fore plane is 18 inches long, and the jointer plane is 22 to 24 inches long. Both the fore and jointer planes are also used for smoothing edges.

(5) Special Planes - The rabbet (for rabbeting edges), combination (for dadoing and grooving), and the circular plane (for planing concave or irregular surfaces) are of less importance to farm carpentry than the jack, smoothing, and block planes. Generally, special planes are used only for finishing type work. The duplex or full nose rabbet planes can be used to plane into corners. The most commonly used rabbet plane is 8 inches long with a ½ inch blade.

Transparencies Nos. 5, 6, 7, and 8

c. Assembling the plane

(1) The plane iron bevel (cutting edge) must be opposite the plane iron cap when the two are put together. It is placed on the cap so that the curved part of the cap will not be dragged over the plane iron edge.

(2) The plane iron cutting edge should protrude from 1/32 to 1/16 inch beyond the plane iron cap, or about one-half the thickness of the plane iron.

(3) The plane iron assembly should be placed on the plane frog so that the plane iron lies on the frog and the lateral adjusting lever.

(4) The lever cap is placed against the plane iron cap, the lever cap screw is fitted in the narrow part of the screw slot, and the cam is pushed down against the plane iron cap.

d. Adjusting the plane

(1) The plane is held upside down, and the protruding cutting edge (1/64 inch or a sheet of paper thickness) is adjusted evenly across the plane bottom. The entire blade should cut evenly.

(2) The depth of cut should be made by turning the adjusting nut that is found in front of the handle. Plane iron setting (angle and depth) may also be made by placing two fingers on each side of the iron or protruding cutting edge.

(3) The block plane is assembled and adjusted in a similar manner as the jack plane except there is no plane iron cap attachment.

e. Using the plane

(1) Holding the board or stock

The board may be placed in a bench vise for edge planing, or a V-shaped block may be used to hold it securely.

A board may be held for face planing by nailing a stop block to the table or by clamping a stop block firmly to a work table.

The board should be held so that face and edge planing are accomplished by pushing the plane with the grain of the wood.

(2) Making the plane stroke

One hand is placed on the handle and the other on the knob, and the plane is placed on the board at the back of the area to be cut before any pressure is applied in making the stroke.

At the beginning of the stroke, pressure is applied on the knob; near the middle of the stroke the pressure should be the same on both front and back of the plane; and at the end of the stroke the pressure should be on the handle of the plane.

The plane can be lifted slightly, the heel lifted slightly, or the plane tilted to prevent dragging the blade over the surface on the return stroke. When not in use, the plane should be laid on its side.

Strokes made by a block plane are short. It is used in one hand with the forefinger placed on the finger rest.

General practices in making the plane strokes include:

End grain should be planed half way from each side unless the corners at the ends and edges are beveled.

When straightening a board, high points should be removed before jointing the entire board. Cutting strokes should be made the full length of the board without removing the plane. A thin shaving should appear throughout the entire stroke.

Beveling or chamfering may be accomplished by making the strokes with the plane held at the desired angle on the board.

The quality of work is the same if the plane cut is straight forward or at a slight angle. Generally, the plane is pushed at an angle on the face of a board. The cut is usually made easier if the plane is held flat on the stock and pushed at a slight angle.

The block plane is the handiest of all hand planes for planing corners and bevels on small pieces of wood. It is especially useful for planing molding ends, trim, and siding. End grain should be planed with a block plane in the same manner as a jack or smoothing plane, with the end grain cut half way from each edge.

(3) Checking the plane cut

A board should be checked for squareness while it is being planed. A block placed on the plane bottom near the knob and against the stock may help determine whether or not the board is square.

The try or framing square should be used to check for high places on the surface that is being planed. If the board or wood stock is too long to check with a square, a straight edge should be used. The square is used to check a true plane surface.

4. Selecting and Using Hand Saws

a. Hand saws continue to be very important tools in a carpentry tool kit or in a well equipped workshop. Crosscut and rip saws are still used for straight sawing in certain types of woodwork construction projects. If there is a limited amount of cut-off and ripping work to be performed, the hand saw

may be preferred over the power saw. Working in close places may require the use of a hand saw. It may be advisable to select the proper hand saw for cutting molding, base boards, and facing materials instead of selecting a power saw for such work. Other reasons for using the hand saw are: power may not be available, work can be completed faster on some jobs, and work is easier when handling light tools in some locations.

Transparencies Nos. 9 and 10

b. Types of hand saws

(1) Crosscut Saw - The crosscut saw is the most commonly used of all hand saws for general farm work. Teeth on this saw are shaped to cut across the grain of wood. From perpendicular, the front of the tooth is 15 degrees and the back 45 degrees. The most commonly used crosscut saws have from 8 to 11 teeth per inch of blade. The length of blade varies from 18 to 26 inches. The longest blade is the most popular. Fast and coarse cuts are made with a small number of teeth to the inch. Ten and 11 point saws are used to cut finishing materials such as moldings and door facings.

(2) Rip Saw - This saw is used to cut with the grain. The overall angles of rip saw teeth are the same as those of a crosscut saw, but the forward angle is only 8 degrees from perpendicular. Teeth cutting edges are square, and the back angles are 52 degrees. The most popular sizes are 24 to 26 inch blades with 5-1/2 to 7 teeth per inch.

(3) Compass Saw - This saw is used to cut curves and circles, starting a cut from a hole bored by a brace and bit, and to cut holes for pipe outlets. The blades taper from back to front. Compass saw blades are 12 to 14 inches in length with 8 teeth to the inch. The shape of the teeth resembles those on a crosscut saw.

(4) Keyhole Saw - The keyhole saw is used to saw "cutouts". It may be found as a single blade saw or a nest of saws (one handle with two or three replacement blades). One of the blades is used for cutting metal. This saw resembles the compass saw, but the standard blades range from 10 to 20 inches with 10 to 15 points per inch. Curves, holes, and straight sawing cuts are usually smoother when done with a keyhole saw than with a compass saw.

(5) Coping Saw - This saw is designed to cut thin or light wood. It is used to cut curves, for scroll work, and shaping the ends of moldings. Blades of this saw are about 1/8 inch wide and are made of thin metal. The overall length may vary from about 6-1/2 to 7 inches with 15 points to the inch.

(6) Backsaw - Backsaws are used to make accurate and smooth cuts. The large backsaw is known as a mitre box saw. They may range in length from about 22 to 30 inches. The width of the reinforced blade varies from 4 to 6 inches.

Small backsaws are found in lengths from 10 to 16 inches, and the number of teeth per inch may vary from about 11 to 15. All backsaws and dovetail saws are reinforced the full length down the back edge of the blade.

(7) Hacksaw - Hacksaws are used to make accurate smooth cuts on metal. Hacksaw frames are designed to take blades of various lengths. The frame can be adjusted to the length of the blade and permit proper tension. Blades are made with 14, 18, 24, and 32 teeth per inch.

c. Proper use of handsaws

(1) Crosscut Saws

Assuming the material is on sawhorses or in a vise, grip the saw handle and place the index finger forward on the handle.

Place the free hand in a position on the material to be sawed so that the thumb can serve as a guide for starting the blade.

Hold the saw blade so that it is at a right angle to the stock and the saw cutting edge is 45 degrees to the surface being cut.

Start the saw cut by placing it on the waste side of the line and use draw strokes until a starting groove is formed. Maintain the 45 degree angle and take long even strokes as the saw cuts through the stock. If pressure is applied, it should be on the downward stroke.

(2) Ripsaw

Use the same procedure when sawing with a rip saw except for changing the angle to 60 degrees.

If the saw is pinched when ripping a long board, use a wedge to spread the pieces apart.

(3) Compass and Keyhole Saws

After the stock has been marked, start the cut by either a light forward or backward motion.

Hold the saw in the proper position. For example, if the cut is to be square, the saw blade must be held perpendicular to the stock.

To cut a hole or cut an area out in a stock, first bore a hole and start the cut in the hole.

Cut curves and holes by slightly twisting the handle in the direction of the cut.

When sawing sharp curves and small holes, use the point or pointed part of the saw blade.

(4) Coping Saw

Check the blade to determine whether or not the teeth are pointing toward the handle and the blade has proper tension. The blade is more likely to kink if the blade is inserted to cut on the forward stroke.

Hold the stock firmly in a vise, bracket, or saddle in order to make a smooth cut.

Turn the blade in the frame to keep the frame from touching the stock. Usually a quarter of a turn is adequate.

Make long, steady, slow strokes. Fast strokes tend to heat the blade and increase the possibility of kinks.

Release the tension on the blade when the saw is no longer used.

(5) Backsaw

Start the backsaw cut in the same manner as a crosscut and ripsaw cut; that is, pull the saw backwards to make the initial cut.

If the saw is used out of the mitre box, the thumb may be used to guide the blade on the line until the saw begins cutting the stock on the forward stroke.

When using a mitre box to cut in either a 90 or 45 degree direction, place the stock in the box nearest the body and use the free hand to hold the stock. The thumb of the free hand is not used to guide the blade, but the index finger is placed along the side of the handle.

Make long even cuts by holding the blade level on the stock, and use an even pull and push motion.

(6) Hacksaw

Properly adjust the blade tension and make sure the teeth point away from handle. Be sure to select a blade that will allow at least two teeth to be in contact with the stock at all times.

Except when starting the cut, use the full length of the blade on every stroke.

Apply pressure on the forward stroke and relieve pressure on the back stroke. Generally, 40-50 strokes should be made per minute.

Transparency No. 11

5. Selecting and Using a Brace

The two-jaw chuck brace is equipped to handle the seven major types of bits discussed in this lesson. The chuck clamps the square shank bit by the bit tang to hold it firmly in place.

Braces range in size from 6 to 14 inches. The size is determined by the brace swing or sweep, that is, the distance across the diameter of the circle made by a complete sweep of the handle. A 10 inch sweep brace is most commonly used to do average work.

The ordinary brace without the ratchet may cost less than the ratchet brace, but its functions are limited. The ratchet permits the boring of holes in places where a full handle turn cannot be made due to obstructing objects. The ratchet works both ways, forcing the bit forward or backward. It can also be set so that the handle will not swing free in the operation.

Corner braces are equipped with two handles and a head. It is used for boring against walls and in corners.

Transparencies Nos. 12 and 13

a. Types of Bits

(1) The auger bit is used for boring holes in wood. The tang on the shank is usually square, depending on the type of brace used. Auger bits range in size from 3/16 inch to about 2 inches. A No. 11 bit will bore a hole 11/16 inch in diameter. The figure 11 is found on the shank. Auger bits are usually found in sizes from 1/4 inch up to 1 inch, graduated in one-eighths of an inch.

(2) The expansive bit is used to bore holes ranging from 1 to 3 inches in diameter. The blade or cutter may be adjusted for different sizes of holes. The expansive bit is similar to the auger bit in that it has a feed screw that draws the bit into the wood. It has only one lip; therefore, it must be held straight.

(3) The forstner bit is also used on wood. It can be used to bore holes for dowel pins and countersinking washers that are used with bolts on wood. The sizes range from 1/4 inch to 2 inches in diameter.

(4) The twist drill bit, which is sharpened with the same angle as the round shank bit for metal, is used for both metal and wood boring. The more pointed bit stock or twist drill is used for wood only. The sizes may range from 1/16 inch to 1-1/4 inches in diameter.

(5) Screwdriver bits are used to set or loosen screws or bolts with slotted heads. The size is determined by the width of the bit blade. The widths range from 3/16 inch to over 1/2 inch.

(6) Countersinks are used to widen the space at the hole entrance for oval or flat head bolts or screws. The head of the screw or bolt is set flush or slightly below the surface. The size is determined by the diameter of cut made by the largest part of the bit.

(7) Gimlet bits are used to make holes for screws in wood. The bit point forms the tapered hole. They vary in size from 1/8 to 3/8 inch in thirty-seconds.

(8) A lock set bit is used to make holes for cylindrical locks. This type of bit is usually used with a lock jig.

Transparency No. 14

b. Placing the Bit in the Brace and Setting the Ratchet

Grasp the chuck shell and brace handle; holding the chuck in an upward position, turn the handle to the left until the chuck jaws are open.

Place the bit in the jaws of the chuck and turn the handle to the right.

Check the bit as the jaws of the chuck are tightened on the tang. The bit must be held firmly between the jaws while it is in use.

When boring a hole in a corner, or some obstruction prevents the full turn of the brace handle, the ratchet should be adjusted as follows:

With the bit pointed in an upward position, the cam ring should be turned to the right to permit the bit to turn to the right for boring a hole.

If the cam ring is turned to the left the ratchet action will be to the right, and the bit can be withdrawn from the wood.

Transparency No. 14

c. How to Start the Hole by Using the Brace and Bit

Steps in starting the auger bit include:

(1) Mark the location of the hole center by crossed lines.

(2) Start the hole with a sharp pointed tool (awl or ice pick).

(3) Grasp the lower part of the bit(twist) and place and hand against the board;

at the same time insert the point of the bit into the hole at an angle.

(4) Raise the bit until it is at a right angle with the work.

(5) Test to see that the hole is being bored squarely by:

Sighting the bit at right angles.

Comparing the bit with the nearest straight edge. The sides of the bench vise that holds the material may be used as a straight edge.

Using a try-square near the bit.

Transparency No. 15

d. Boring the Hole

(1) Applying Pressure on the Brace

Pressure is applied by one hand when boring a vertical hole. Usually, the left hand is used to put pressure on the head of the brace.

When boring a horizontal hole, the left hand is placed over the brace head, and the thumb and forefinger are placed around the quill. The stomach puts pressure against the left hand.

(2) How to Prevent Splintering, Splitting, and Making a Counterbore

When boring a hole through a board, splintering can be prevented on the second face by stopping when the screw point is felt. The auger bit point should be entered in the point hole on the second face to complete the hole.

It is best to clamp a board to the second face piece of material when using an expansive bit.

Splitting is prevented when drilling large holes in thin or narrow pieces of wood by either placing the piece in a vise so that the jaws protect the edges or by first boring the hole with a small twist drill and then drilling with a larger twist drill.

When countersinking for bolt or screw heads, the hole should be made before the counterboring.

Transparency No. 15

e. Determining the Proper Depth When Boring a Hole

Methods to use when boring holes to a certain depth are:

(1) Wooden Stop - A small block of wood center bored, with the bit projecting from the block to the desired depth of the hole, is most satisfactory.

(2) Metal Bit Stop - This type of bit stop is attached to the bit by a wing nut. It can be moved up and down the bit twist.

After the cutting lips touch the wood, a rule will show the distance from the wood surface to the chuck. Measurements can be made as the hole is being drilled. If several holes of the same depth are to be made, it is best to use a block cut to fit under the chuck.

Transparency No. 11

6. Selecting and Using Drills

a. The three major types are:

Hand drills
Breast drills
Push drills
Hand operated drill press (not a major type)

b. Hand drill purposes include:

Drilling small holes, either in wood or metal, 1/4 inch or less in diameter.

Form holes or openings for screws, nails, bolts, and other materials where openings are necessary.

c. Push drills are used mainly to bore holes for small screws in wood and other soft materials. A push drill is made to bore a hole less than 1/4 inch in size. Most push drills have a set of bits ranging from 1/16 to 11/16 in size stored in the handle. This drill may be operated by one hand while the other hand is left free to support the work.

d. Breast drills are designed for heavier work than either hand or push drills. They are usually constructed with adjustable handles and two speeds. The drill is made to bore a hole up to 1/2 inch. The breast drill is for general purpose work in metal and wood.

e. General Characteristics of the Drill Parts

(1) Chuck (has three jaws) holds the bit in place.

(2) Pinion is the small gear attached to the main frame which is turned by the speed gear.

(3) Crank handle is attached to the speed gear on hand and breast drills.

(4) Handle is the top part of the main frame held by the hand when operating the drill.

(5) Speed gear turns the pinion gear and pinion idler on the hand drill. A breast drill may have only the pinion gear.

(6) Frame supports gears, handles, and chuck.

(7) Side handle is located opposite the speed gear on a hand drill and above the chuck on a breast drill.

(8) The push drill is made up of a chuck, chuck sleeve, spiral spindle, locking ring, and handle.

(9) The breast drill has a breast support or plate, whereas the other two drills have handles. Most hand drills and push drills have magazine handles (they hold bits).

Transparency No. 16

f. Inserting and Removing the Bit

(1) Hand drill bits are inserted in the following manner:

Hold the chuck and turn the crank backward to open the jaws slightly larger than the bit diameter.

Center the bit and tighten the chuck by holding it firmly and turning the crank forward.

The bit is removed by holding the chuck and turning the crank backward.

(2) The procedure to insert and remove the bit from the breast drill is the same as that of the hand drill.

(3) The push drill chuck sleeve is pushed forward to insert the bit. It is also pushed forward to release the bit.

Transparency No. 17

g. The Proper Way to Use a Drill

(1) The hand drill should be held firm and steady while in use, regardless of the angle it is used on the work.

(2) The handle of the hand drill may be held against the body, releasing the hands for the crank and side handles. This is the way a breast drill is used.

(3) An even pressure should be exerted on the handle or handles. The crank should be turned at a steady speed and not too fast.

(4) The push drill is used with one hand placed on top of the handle. The return spring causes the drill to unwind on the backward stroke, which helps clean the hole and forces the bit into a cutting position.

(5) The steps to follow when drilling a hole are:

The center of the hole should be marked with an awl or similar tool for drilling soft material and with a center punch for metals.

Select a drill bit of the proper size (the diameter of the cutting part may be slightly smaller than the large part of the screw or bolt for soft materials, and it should be the same size for metal materials).

The stock being drilled should be held firmly, either in a vise or by other means.

On metal, a drop or two of oil should be used at the place of drilling.

The pressure should be eased as the drill breaks through the surface.

A small pilot hole made by a small bit is necessary in forcing a larger bit through certain woods or metals.

To drill to a certain depth, a depth gauge may be made from a piece of wood. The piece of wood is drilled and slipped over the bit.

To clean a drilled hole, the bit should be turned in the drilling position as it is withdrawn from the stock. The bit should be removed frequently during the drilling process to clean the hole.

7. Selection and Use of Wood Chisels

a. Wood chisels are selected according to the type of work that is to be performed. Naturally, a 3/4 inch dado work will require a chisel larger than 1/4 inch and smaller than 7/8 inches. A 1/2 to 5/8 inch chisel will permit working room for notching out and smoothing the 3/4 inch dado surface.

b. Wood chisel sizes vary from 1/8 to 2 inches. The length of blade ranges from about 3 to 6 inches. Long lengths are called firmer chisels. Medium lengths are called pocket chisels. Short lengths are call butt chisels.

Transparency No. 18

c. Wood chisels are also classified according to the type of handle attachment.

Socket Chisels - This is the most common type of chisel used in farm carpentry. Due to the handle being fitted into a steel socket, the chisel can withstand harder blows from the mallet. These chisels are used for rough woodwork and framing. The most common sizes are 3/8, 3/4, and 1-1/2 inch.

Tang Chisel - The handle of a tang chisel is similar to that of the socket chisel except that the tang is fitted into the handle. Less driving pressure should be applied to the tang chisel than to the socket chisel. Tang chisels are better for hand work, such as paring, because of their light weight and balance. The tang of a chisel is the spike-like or file-like handle part of the chisel fitted into the handle. This type of chisel usually has a plastic handle.

Transparency No. 19

d. Steps in Making a Cut with the Wood Chisel

(1) The board of work should be fastened firmly. A vise is the best method to use for short wood stock.

(2) The chisel cut should be made with the grain to prevent the board from splintering or splitting.

(3) One hand should be used to guide the chisel blade, and the other hand should be moved slightly from right to left as pressure is applied to the chisel handle.

(4) The bevel should face down when making rough cuts, and it should be face up when paring or finishing materials.

(5) The first cut over a surface may require the use of a mallet, whereas the finishing cut of the same work should be done by hand. This method of chisel cutting is used mainly for making joints.

e. The Different Uses of the Wood Chisel

Transparencies Nos. 20 and 21

(1) Dado Trimming

Wide dadoes should be cut several times with the saw and the large portion of the material removed by the mallet and chisel.

Trimming should be half way from each edge of the cut and at the same time in an upward direction. The center should be trimmed last.

(2) Notch Edge Trimming

After the notch is marked out accurately several cuts should be made with the saw.

The larger portions should be removed with the chisel and mallet.

Trimming or smoothing should be made in the same way as the dado cut.

(3) Curve Trimming

An outside or convex curve can be finished with a wood chisel after about three straight cuts are made along the curve line.

The chisel bevel should be up while trimming around the curve.

Inside curves should be trimmed with the bevel down. Most inside curves are usually first cut with a sabre or keyhole saw.

(4) Paring Chamfers or Cutting a Bevel

Chisels are used similarly to a plane to make a slight bevel on a board. The bevel side is up when making a cut.

To prevent splitting, the bevel should be made with the grain first, then follow by working the chisel at an angle along the end grain.

(5) Mortise-and-Tenon Joint

The area is marked off for a mortise according to the size of tenon to be used (mortise is a hole cut into a board, and a tenon is the cut that is inserted into the mortise).

A brace and bit can be used to cut out the tenon area, leaving shaping-up for the chisel, or the chisel can be used to make the entire cut.

The rough work is made with the mallet whether or not a brace and bit are used, and the trimming or finishing is done by hand, without the use of the mallet.

(6) Trimming End Grain of a Dado

The flat surface of the chisel should be on the end grain at an angle and the handle brought upward as the cut is made.

The flat side of the chisel should leave a cut equal to the original end grain cut.

(7) Rabbet Trimming

Rabbeting requires the use of several saw cuts if the second piece of board is large. (A rabbet is a groove cut into the edge or end of a board to receive another board.)

Chiseling may be used for finishing. Chiseling a rabbet joint is similar to chiseling a dado; the flat side is held against the board surface.

(8) Installing Butt Hinges with a Chisel and Mallet

The area is marked off according to the hinge size.

The wood is chiseled out by leaning the chisel slightly toward the flat side and tapping it with the mallet.

The area is trimmed out without the use of the mallet by working the chisel with the flat surface against the cut.

f. The Common Wood Joints that may be Trimmed by Use of the Wood Chisel

Dado	Middle lap
Mortise-and-Tenon	End lap
Rabbet	Mitre
Cross lap	Half lap

g. Care of the chisel while in use

The chisel should be laid on a table with the bevel down to protect the cutting edge.

The wood chisel should be kept sharp and the cutting edge protected for all metal.

A chisel, like all other tools, has a certain purpose and should be used for that purpose. It must not be used to pry open containers, used as a screwdriver, and the hammer should never replace the mallet to drive the chisel.

Transparency No. 22

8. Selecting and Using Screwdrivers

a. Types of screwdrivers are:

(1)	Standard	(5)	Phillips
(2)	Starting	(6)	Screwdriver bit
(3)	Clutch-head	(7)	Offset
(4)	Spiral-Ratchet		

b. Parts of the standard screwdriver are.

(1) Tip (2) Blade (3) Ferrule (4) Handle and (5) Head.

Transparency No. 23

c. Factors affecting the use of screwdrivers are:

(1) Screwdriver should be matched with job.
(2) The tip should be square.
(3) The tip should be the correct size.
(4) The handle should be tight.
(5) A marred screw head will be a problem.

Transparency No. 24

d. Using the Different Types of Screwdrivers

(1) Standard Screwdrivers - The handle is placed in the palm of one hand and the blade is guided with the other hand by holding it near the tip. The blade is kept parallel with the screw or bolt as it rotates. The hand near the tip keeps the tip square on the screw head as a new grip is placed on the head or handle.

(2) Spiral-Ratchet Screwdrivers - This screwdriver can be used in awkward places for driving or drawing screws. One hand is placed on the handle without releasing the grip. The other hand is placed on the chuck. The handle is pushed straight.

(3) Screwdriver Bit - This bit may have a tapered or round shank. If it is used with a ratchet brace, a quarter or half turn will keep the bit from slipping in the screw slot. Pressure and balance are supplied by both hands on the brace when driving a screw into the wood. Large screws can be driven more easily with bits than with the standard screwdriver.

(4) Phillips Screwdrivers - This screwdriver has a special slanted tip that is cross-shaped to fit into a Phillips cross-shaped screw slot. The driving method is the same as for the standard screwdriver.

(5) Offset Screwdrivers - The offset screwdriver is used to drive screws in close places where other types of screwdrivers cannot be used. There is a short blade on each end, bent in the opposite direction and at right angles to the handle. One of the blades is in the same plane as the handle. Usually it is necessary to use both ends in driving a screw.

e. Steps to Consider in More Efficient Use of the Screwdriver

(1) Bore the first hole as near the size of the screw shank as possible in the first piece of material.

(2) Bore the second hole slightly smaller than the screw root but only half the distance of the threaded part for soft wood.

(3) Countersink screw heads for flat and oval head screws. The countersink should equal the diameter of the screw head, and it should be in the larger hole.

If a round-head screw is sunk below the surface, a twist drill may be used instead of a countersink. The screwdriver blade should be small enough not to damage the counterbore or surface. Flat head screws are used when plugs or dowel are inserted above the screw head.

Where very hard wood is fastened together, it may be necessary to bore a second (anchor) hole the length of the screw threads. Soap, oil, or water will make the screw enter more easily in hard wood.

Holes for very small screws can be made with an awl or other sharp, pointed instrument. This practice makes it easier to use the screwdriver.

Screws can be tapped lightly with a hammer only to set the screw in a small pilot hole before driving it into the wood. Note: A heavy blow with the hammer will mar the screw head, and if driven too deeply with the hammer, the thread-holding effect will be reduced.

f. Misuse of the Screwdriver

(1) The screwdriver is not a pry tool; therefore it should not be used to replace such a tool.

(2) Even though the screwdriver blade is bradded on top of the handle or permanently set in a sturdy handle, it should not be used as a chisel, nor should a hammer or mallet be used on it.

(3) Screwdriver blades are usually either round or square. If a screw is hard to withdraw or set, pliers and wrenches should not be used on the blade to give the screwdriver extra power. The screw head may be sheared off or the tip of the screwdriver broken.

(4) In some cases screwdrivers are used as mixing tools for paints, glues, and oils. Unclean tips will slip out of the screw slots; therefore, they should not be used as a mixing paddle.

Transparency No. 25

9. Selecting and Using Measuring Tools

a. Measuring and marking tools are important; they are used to check and determine inside and outside measurements, clearances, and alignments. Without measuring devices quality of workmanship would be poor.

b. Types and uses of measuring devices are:

(1) Feeler gauge - This device can be used to determine ignition point gap, air gap, valve gap, piston ring gap, and other tolerances.

(2) Outside caliper - This device can be used to measure and/or transfer outside dimensions.

(3) Inside caliper - This device can be used to measure and/or transfer inside dimensions.

Transparency No. 26

(4) Steel rule - Standard measurements are the foot, inch, and fraction of an inch. The rule is usually divided into one foot, one inch, one-half inch, one-fourth inch, one-eighth inch, and one-sixteenth inch.

Transparencies Nos. 27 and 28

(5) Carpenter's framing square - This device is L-shaped, the body is 24 inches long and 2 inches wide, and the tongue is 16 inches long and 1½ inches wide. It may have the following tables on the tongue and blade: brace table, rafter table, octagon table, and the essex table.

Some Uses of the Framing Square Are:

Boards are squared for cutting by placing the blade firmly against the edge of the board and marking against the tongue.

Another use is to lay out angles by observing a certain distance of the blade and the tongue as used for rafter cutting or making polygons and cutting at 45 degree angles. For example, using the same number on the blade and tongue (6 inch blade and 6 inch tongue), certain points on the edge of the board will give a 45 degree cut or angle. It also can be used for measuring length.

(6) Try and Miter Square - The handle and blade form two angles, 90 and 45 degrees, the same angles as found on the combination square. The blade ranges from 6 to 12 inches in length.

(7) Try Square - The try square most commonly used is a six inch blade. The handle is not used for measuring. The blade is graduated into one inch, one-half inch, one-fourth inch, and one-eighth inch. Actually the blade length may vary from 6 to 12 inches.

It is used mainly to test the squareness or accuracy of cut. This square may also be used for short measurements and laying out lines across the face of a board from the edge. The try square is similar to the framing square in that the hand and blade form a 90 degree angle.

(8) Combination Square - The combination square consists of a face and head. The head is equipped with a spirit level. The blade is of several different lengths, but the 12 inch blade is most commonly used. The common head

has a 90 and 45 degree angle to the blade. It is attached to the blade by a slot in the blade's center. The head can be moved up or down on the blade. It is graduated from one inch to one-sixteenth inch.

The square can be used as a marking gauge, straight edge, try square, level, depth gauge, plumb, or mitre square. With a center head attachment, it can be used to locate the center of round objects. With a bevel-protractor head, angles can be marked in degrees. The blade can be used for measuring short lengths.

(9) T-bevel Square - The most common type has a six inch blade with a 45 degree beveled end. The blade has a long center slot which permits its movement to form a T-bevel or angles. It is usually not graduated.

The main purpose of the T-bevel square is to transfer angles, bevels, and chamfers from one stock to another. It can be set an any angle by tightening the blade screw; therefore, several boards can be cut at the same angle.

(10) Folding Extension Rule - The zigzag rule is usually six feet in length. It is graduated from one inch to one-sixteenth inch and can be read both ways from left to right and right to left. Some of the more expensive rules have a six inch extension which permits making inside measurements of objects such as door and window facings.

Long measurements may be made with the zigzag rule. It folds every six inches and should be handled with care while folding, due to its being thin and long. The framing square is used to square a board after the rule has been used. Another way to use the rule on boards over 12 feet is to unfold the rule completely, mark off six feet from each end, then mark the center between the two six feet points.

(11) Push and Pull Rule - The push and pull rule is similar to a tape in that it rolls inside a round metal case. The metal rule is available in many lengths. The most commonly used length is 10 feet. It is graduated in inches. Only one side of the rule is numbered, but both edges of the numbered side are graduated in sixteenths of an inch. Some rules are graduated for the first few inches in thirty-seconds of an inch. Several types of pull-push rules are equipped with a rewind mechanism.

The push and pull rule is for measuring layout work of both short and long objects. The size of the rule permits it to be carried in the pocket. Curved or irregular surfaces may be measured by this metal rule due to its flexibility. When making inside measurements, the 2 inch metal case is added to the measurement.

(12) The Steel Tape - Steel tapes are found in standard lengths of 25, 50, and 100 feet. The tapes are graduated in feet, inches, and usually to

one-eighths of an inch.

Tapes are used to make long measurements, and only one person can use the tape effectively if the ring at the end or starting point is hooked in place by a nail or other holding device. The tape is used on foundations, drive layouts, and many landscaping jobs.

Transparency No. 29

(13) Marking Gauge - The marking gauge is used to make parallel lines from either the edge, side, or end of a board. The setting of the gauge is made by the use of a rule. A reading is taken from the spur to the gauge head by a rule. It is necessary that the gauge head be pushed forward against the stock so that the spur moves at a slight angle.

(14) Other Marking Devices

The combination square serves as a marking gauge by placing the head against the surface of the stock and adjusting the blade to the desired distance. A pencil or sharp-pointed instrument is placed at the end of the blade as it is moved by a pulling motion. Both hands are used to handle the square and pencil.

When using a rule or straight edge, the thumb or finger regulates the distance to project the end of the rule over the board for marking. A pencil or sharp-edged instrument is used at the end of the rule to make a mark as it is pulled forward. Both hands are needed to manipulate the rule and pencil; therefore, the stock should hold firmly by some means, permitting the hands to be free for marking.

When using the thumb or finger as a guide and using only a pencil for marking, it is necessary that the starting point be measured by a rule. This method is less accurate than the use of a marking gauge or a combination square.

Dividers are a device used for making circles, transferring short measurements from a rule, and dividing measurements into equal parts.

Either rules or squares of different types may be used to find the center or even parts on the board. For example, to find the center of a board that is 5-5/8 inches, the 2 inch mark of a rule can be placed on one edge and the 8 inch mark placed on the other edge. The rule will be at an angle on the board, but a mark at five on the rule will be the center. Marks at four and six on the rule will divide the board into three equal parts. Odd numbers can be determined by dividing the number by the desired number of pieces.

Inside measurements may be made by using the extension on the six foot folding rule by placing two bench rules together if the distance is between two and four feet and then taking the overlap readings, or by using two pieces of boards, each end touching the inside of the object (door or window facing) and marking the end of each where they overlap. The distance may be transferred to a rule for making a correct measurement.

The most common marking devices include pencils, knives, awls, and chalk lines. In some cases narrow wood chisels have been used.

Transparencies Nos. 30 and 31

(15) Micrometer Types

Outside - The outside micrometer is used tc check the diameter of pistons, crankshafts, pins, and camshafts and the outside dimension of other parts in thousandths of an inch. The thimble is turned until an anvil face and spindle face touch the object.

Inside - This type of micrometer is used to determine the measurements in cylinder bores, brake drums, and certain bushings. There are two types -- for small and large measurements. The thimble is turned to spread the jaws apart until they touch both sides of opening.

Depth - The depth of openings such as slots and holes are measured by the depth micrometer. The base is placed over the opening, and the pin is run down by turning the thimble until the pin reaches the bottom of the hole or opening. There are several different widths of depth gauges used on depth micrometers.

(a) The principal parts of an outside micrometer include:

Rachet stop	Frame
Thimble	Anvil
Barrel	Measuring faces
Spindle	

The thimble and barrel are marked with scales for making measurements.

(b) There are two major measurements used on micrometers. One type of micrometer is graduated in hundredths of a millimeter. This is a metricmeasure micrometer. The other type is graduated in thousandths of an inch and is called an English measure micrometer. Steps in using a micrometer are:

Select the proper size of micrometer for making the measure-

ment and adjust the opening a little larger than the thickness of the object to be measured.

Place the thimble between the thumb and forefinger and turn the thimble until the spindle and anvil points contact the object being measured.

Turn the rachet two clicks, that is, if the micrometer is equipped with a ratchet. If a non-ratchet type is used, pressure is determined by "feel". Do not tighten the thimble so that micrometer cannot be easily removed from the object.

If possible, take the reading while the micrometer is attached to the object. The reading may be taken after the micrometer is removed if care is taken not to move the spindle.

Readings may be made with calipers in places that are hard to measure with the micrometer, and the reading may be transferred to an inside micrometer.

Take the reading by using the following procedure:

Read the highest figure on the barrel.

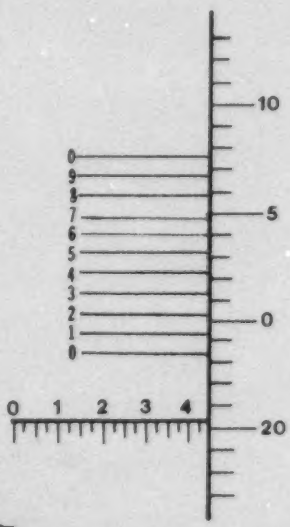
Read the number of lines that are visible on the barrel above the highest figure.

Read the thimble line that is in line with the datum line.

If the micrometer has a vernier scale, read only the vernier scale line that coincides exactly with the thimble line.

Micrometer readings without and with a vernier scale:

A.



B.

A.	Sleeve or barrel	3 = .300	B.	Sleeve or barrel	4 =	.400
	Sleeve or barrel	2 = .050		Sleeve	1 =	.025
	Thimble	2 = .002		Thimble	20 =	.020
	Total	.352		Barrel-Vernier	=	.0006 (6/10,000)
				Total		.4456

Transparency No. 32

10. Selecting and Using Files

The file is used for smoothing and shaping metals. Shaping actually includes three types of file use: sharpening of tools, smoothing metal surfaces, and cutting metal to the desired form and dimensions. A regular mill file can also be used to test the hardness of metal. The degree of hardness will determine the type of metal cutting tool and/or the type of hacksaw blade to use for making the cut.

a. Files are selected according to their many uses. The use of a file determines the size, type of teeth, coarseness, and shape.

(1) File Sizes - File sizes are determined by the length of the file (in inches) excluding the tang or the distance from the point to the heel. A 10-inch mill file is used for general purposes. A 12-inch flat file is best for rough work and will last longer than a 10-inch file.

(2) File Teeth - There are two major kinds of file teeth, single-cut and double-cut. Single-cut files have chisel-like teeth running at an angle across the belly and body of the file. Double-cut files have two sets of teeth or chisel cuts that cross each other. Single-cut files cut slower than double-cut files, and they leave a smoother surface.

(3) Grades of Teeth Coarseness - The grade of coarseness is determined by the distance between the rows of teeth. For example, the longest spacing is called rough, and the least spacing is dead-smooth. Naturally, the coarseness changes with the length. A long file is coarser than a short file.

(4) File Shapes - The shape or style is also determined by the different uses. The most common are mill, flat, square, round, half-round, and taper or three corner files. A description of these files is as follows:

(a) Mill files are made only with single-cut teeth and range in size from 4 to 16 inches. They are used for drawfiling and finishing work such as finishing brass and bronze metals.
(b) Flat files are double cut and about 4 to 16 inches in length. They are tapered similar to the mill file and are the most commonly used of all files for general work.
(c) Square files have four filing edges instead of two as found on the mill

and flat files. They are tapered or blunt and double-cut. This kind of file is used for filing corners and slots and for surface filing.

(d) Round files are single or double cut. They are used for enlarging holes, filing curves, and forming fillets. These files are tapered from shoulder or heel to point.

(e) Half-round files have one flat side and one partly round side (about one-third of a circle). This type of file is double-cut, and it can be used to file either flat or curved surfaces.

(f) Tapered files are found in many shapes. The triangle, contour, and crosscut files are the most popular. They are double cut and are used to file corners that are less than 90 degrees and to file saws.

Transparency No. 33

b. There is a correct way and many incorrect ways to hold a file for both heavy and light filing.

(1) Heavy Filing - The handle is held in one hand by placing the thumb or forefinger on top of the file handle and gripping the point with the fingers and back part of the thumb.

(2) Light Filing - The handle may be held the same way as in the heavy filing method. The file point is held between the first two fingers and thumb, applying light to moderate pressure as needed.

c. The steps to follow when using a file to shape metal are:

(1) Clamp the stock (metal) slightly above the jaws of the vise to eliminate vibration while filing. The area being filed should be about elbow height or slightly below. Chattering can be reduced or almost eliminated if the stock is placed just above the jaws of the vise.

(2) Select the proper type file to cut the stock. For example, if the surface is to be filed flat, select a flat file.

(3) Stand slightly to one side of the work, yet facing it so that the right amount of pressure can be applied on the forward stroke.

(4) Use moderate speed strokes. However, hard metal is filed slower with more pressure than mild or soft metal. About 30 strokes per minute may be appropriate.

(5) Except for draw filing, hold the file at a 90-degree angle to the side of the stock when making filing strokes on flat metal.

(6) Make a slow, full-length stroke by placing the file on the stock and pushing it forward; lift it on the back stroke. Moving the file back, permitting it to slide over the metal, will dull the teeth faster than pushing the file forward. If there is a possibility of the file slipping off the stock on the forward stroke and marking or damaging the jaws of the vise, the stock should be clamped between two pieces of board.

(7) Check the stock with a square during the filing process to see if a proper cut is being made. A 90-degree cut is easily checked by using a try square. It may be necessary to file the stock by holding and pushing the file in a diagonal position to keep the surface flat.

(8) Clean the file periodically while it is being used. Cleaning tools are a wire brush or file card. Hard-to-get chips can be removed with a clean wire. Some of the chips can be removed by tapping the file on the work bench. Cleaning can be aided by starting the file body at a different place on each forward stroke.

d. Drawfiling is a method of filing long, flat surfaces and rods. It is also used to smooth rods that may require considerable hammering. The method is as follows:

(1) After the stock has been clamped high enough in the vise to clear the fingers, grasp each end of the file, placing it on the stock with each thumb clearing the stock by about 3/4 inch. Use a mill file which is single-cut.

(2) Apply steady pressure as the file is pushed forward. Release the pressure on the return stroke. Actually, when drawfiling, the file is pushed sideways for cutting. Always hold the file flat while the moderately slow strokes are being made on the stock. It may be necessary to clean the file often when drawfiling mild or soft metals.

e. It is important to test metal for hardness before attempting to file it. Generally, it is advisable to place the metal stock in a vise in order to run the file over its surface an inch or two to determine metal hardness. Cutting characteristics of five different types of metal include:

(1) Extremely Hard Metal - The file will slide over the metal, leaving the file dull and shiny. The file must be harder than the material being cut, and it should not be used on hardened steel.

(2) Hard Metal - The file may barely cut into the metal, but it is dulled if considerable pressure is applied.

(3) Medium Hard Metal - This type of metal can be filed without dulling the file immediately.

(4) Soft Metal - The file teeth bite into the metal very easily and become clogged with metal particles. Soft metal is cut without dulling the file. Very little

pressure is applied to the file when cutting soft metal.

(5) Cast Iron - The outer surface of cast iron is considered very hard; therefore, an old file should be used to cut through the outer surface before using a new file. If scale is present, it should be removed with a chisel and hammer before attempting to file the surface.

f. A file requires special care if it is to be used over a long period of time. The following suggestions may be observed:

(1) Store files in racks away from other metals. If they rub or fall against other files or tools, the teeth may be damaged. Files are very brittle and may be broken if allowed to fall on concrete floors.

(2) Keep files away from oils, paints, and caulking compounds, as these materials clog the teeth. Also, the file may corrode if placed in a humid or moist location for a long period of time.

(3) A file should never be used without a well seated handle on the tang. Recheck the seating before storing.

Transparency No. 34

11. Selecting and Using Punches

a. Types of punches are:

(1) Starting punches - The starting punch has a long gentle taper from the tip to the body. It is used to knock out rivets and to start driving out straight or tapered pins.

(2) Pin punches - The pin punch is used for driving out pins after the starting punch can no longer be used.

(3) Center punches - The center punch is used to mark the location of a hole to be drilled and so eliminate drill "wandering". Mating parts can also be marked with the center punch to show relationship for reassembly. The correct tip angle is 60 degrees.

(4) Aligning punches - The aligning punch is used to shift parts so that corresponding holes will line up.

NOTE: The correct punch should be used for each job. Never confuse the nail set for a punch. It is to be used only for setting the heads of nails below the lumber surface.

b. Using a punch

When using punches, select the right one for the job, and hold it with a steady, but rather loose grip to lessen the blow on the hand in case of a hammer miss. Always use a correctly sized hammer. Eventually, the head of a chisel will become mushroomed, and should be ground down to prevent injury.

Transparency No. 35

12. Selecting and Using Cold Chisels

a. Types of cold chisels are:

(1) Flat chisels - The flat chisel is the most used chisel. The cutting edge should be slightly convex. This causes the center portion to receive the greatest shock, thus protecting the weaker corners. For general use, the angle of the cutting edge should be 60-70 degrees.

(2) Cape chisels - The cape chisel is used for cutting keyways, narrow grooves, and square corners.

(3) Round nose chisels - The round nose chisel is used for cutting semi-circular grooves and chipping inside corners.

(4) Diamond point chisels - The diamond point chisel is used primarily for cutting V-grooves.

Transparencies Nos. 35 and 36

b. Using cold chisels

(1) The head of a chisel will eventually mushroom and should be properly ground in order to be safe to use.

(2) When chipping, always wear safety glasses.

(3) Cold chisels are used for shearing metal, breaking rivets, and splitting nuts.

(4) Hold the chisel between the thumb and forefinger about an inch from the chisel head. Hold it steady, but loosely gripped to lessen the blow in case of a hammer miss.

(5) The chisel is designed to cut metal softer than itself.

(6) Select a chisel sized for the job and the larger the chisel, the heavier the hammer should be.

13. Selecting and Using Taps and Dies

a. Purposes of taps and dies are:

(1) Die - A die is a tool used to cut male (outside) threads on round-rod metal, so that it can receive nuts with the same thread or be screwed into a hole containing the same thread as the bolt or rod. The die is held in a die stock while being used. The die stock also holds the guide.

(2) Tap - This tool is used for cutting threads inside a nut or inside a hole. The threads of the nut or hole must be of the same type as the bolt or rod that is to be used with it.

Transparencies Nos. 37 and 38

b. Types of taps and dies and other equipment are:

(1) Taper - The taper tap is used to make threads in holes that are drilled through the metal. Note the long gradual taper.

(2) Plug - The plug tap is a very important tap in agricultural mechanics shop. It is used to follow the taper tap in making threads in holes that are not drilled all the way through the metal.

(3) Bottoming - The bottoming tap is not tapered at the bottom, and the threads are the same size from the top to bottom. It is used to follow the taper and plug tap in holes that do not pass through the metal.

(4) Machine screw - The machine screw tap is used for small diameter fine thread jobs.

(5) Two piece - The two piece die is made up of two threaded cutting jaws, collet, setscrew, and guide. Jaw adjustment is made by the setscrew located in the collet.

(6) Solid - The collet of the solid die resembles the adjustable or round-split die, except that it has no slit or setscrew. The solid die cannot be adjusted.

(7) Round-split - Adjustment of the round-split die is made by a setscrew in the slit.

(8) Other equipment needed - Included should be a die stock, tap wrench, vise, oil, flat file, and punch.

Transparency No. 39

c. Threading a bolt or rod

(1) Bevel the edge of the bolt by using a file or grinder.

(2) Place the bolt in a vise to hold it firmly while threads are being cut.

(3) Select a die of the proper size and place it over the bolt, guide first, and apply pressure as the turn is made clockwise.

(4) After the first complete turn, apply a lubricant and thereafter apply the oil about every third turn. (When threading cast iron, oil should not be used.)

(5) The die may be turned the desired length of the thread, except in the case of small diameter dies when the die flutes fill with loose metal and begin tearing the threads. The loose metal may be punched out of the flutes or the die may be turned back one-fourth turn each full turn. The backward movement breaks the chips that form on the forward turn.

(6) Remove the majority of all chips from the flute before removing the die from the bolt.

(7) If the bolt is being cut for a particular nut, try screwing it on a bolt of the same size in diameter and the same type of threads being cut or cut a few threads and try the nut on the bolt.

(8) Hardened steel rod should not be threaded with a die. The die must be harder than the metal it is to cut.

d. Tapping a hole

Select a twist drill for the proper size of hole to be threaded. The size of a drill is usually determined by a chart or by using the second visible thread on a taper tap. A hole that is too large will give incomplete threads. A hole that is too small will cause too much pressure to be put on the tap.

Secure the stock or nut being tapped so that it will not move from the tapping position.

A downward pressure should be applied on the tap at the same time it is turned in the hole. After the tap begins to take hold of the metal, the pressure is released.

Apply a lubricating oil to the tap operation as applied in the die operation.

The flutes of a tap can be kept clean in most cases if a one-fourth counter-clockwise turn is made after each full turn.

Clean the tap flute before removing it from the hole.

e. General information for tapping and threading

(1) Coarse (NC) threads are used on braces, bolts, and adjustment rods in farm machinery. Fine (NF) threads are used on tractors, cars, and trucks.

(2) Agricultural mechanics shops may select a tap and die set (screw plate) that will cut NF and NC threads. A screw plate set that will cut 1/8 inch standard pipe threads, 4-36, 6-32, 10-24, and 12-14, machine-screw threads, and NF and NC threads from 1/4 inch to 3/4 inch will meet the needs of most shops. 4-36 is a number four screw with 36 threads per inch.

(3) The tap sizes and drill sizes for bolt threads are as follows:

Size of Bolt Thread	National Coarse (NC)		National Fine (NF)	
	Tap Drill Size	Threads Per Inch	Tap Drill Size	Threads Per Inch
3	47	48	45	56
10	25	24	5/32 or 21	32
1/4"	13/64 or 7	20	7/32 or 3	28
3/8"	5/16	16	21/64	24
1/2"	27/64	13	29/64	20
5/8"	17/32	11	37/64	18
3/4"	21/32	10	11/16	16

(4) Rethreading is necessary when the threads are marred on a bolt. The same type and size of die is used to correct the threads as those used to make the original threads. The use of the die is the same for threading and rethreading a bolt.

(5) The following precautions should be observed while using the screw plate set.

(6) If a tap breaks in the metal, it may be advisable to grind it level with the surface and leave it in the metal. Taps are made of a very hard metal and usually cannot be removed by drilling.

(7) Due to the hardness of the metal in taps and dies, the small sizes are very easily broken. Also small taps must be held completely straight while tapping a hole. Taps may be burned due to over-heating when entering a hole.

(8) The bolt, rod, nut, or stock must be held in a vise or other methods can be used in such a way that all movements will be eliminated while threads are being cut. Usually bolts, rods, and holes are threaded in a vertical position.

Transparency No. 40

14. Selecting and Using Cutting Tools

a. Types and uses of cutting tools are:

(1) Bolt cutter - Bolt cutters are used for cutting round metal stock or bolts.

(2) Metal shear - The metal shear will make precision cuts on sheet metal and heavier metal stock.

(3) Sheet metal snips - Sometimes referred to as tin snips or hand shears, sheet metal snips are used in scissor action cutting on light gauge metal.

(4) Pipe cutter - The pipe cutter can be adjusted for various pipe diameters. The cutter is adjusted after several revolutions are made enabling the cutter wheels to eventually cut through the pipe.

(5) Tubing cutter - The tubing cutter operates on the same principle as the pipe cutter. Tubing cutters are used on thin wall stock such as conduit and copper tubing.

15. Selecting and Using Wrenches

a. Wrenches may be classified as fixed jaw, adjustable jaw, or special purpose. Several rules of thumb apply when using wrenches, some of these are:

(1) Never hammer on a wrench.

(2) Never use a pipe to increase leverage on a wrench.

(3) Be sure that the wrench fits the nut or bolt head.

(4) Always pull on a wrench, don't push.

(5) Apply pressure on adjustable wrenches so as to protect the jaw.

Transparencies Nos. 41, 42, and 43

b. Types of wrenches are:

(1) Fixed jaw

(a) Open end

(b) Box end
(c) Combination
(d) Hook spanner
(e) Tubing

(2) Adjustable jaw

(a) Vise grip
(b) Adjustable
(c) Monkey
(d) Pipe
(e) Adjustable hook spanner

(3) Special purpose

(a) Sockets and handles
(b) Torque (measures resistance to turning)
(c) Allen or set screw

Transparency No. 44

16. Selecting and Using Pliers

a. Types and uses of pliers are:

(1) Diagonal cutter - Diagonal cutter pliers are used for cutting only small gauge wire and are ideal for pulling cotter pins from slotted nuts.

(2) Side cutter - Side cutter pliers are used when cutting large gauge wire.

(3) Needle-nose - Needle-nose pliers are used for handling small objects and for reaching into restricted areas.

(4) Lock-grip - Lock-grip pliers are used to clamp and hold round objects. One jaw adjusts to fit different sizes of nuts, bolt heads, pipes, and rods. The finish on the material clamped will be marred by lock grip pliers.

(5) Combination - Combination pliers are used for holding work, not for tightening or loosening nuts. The slip joint permits the jaws to be opened wider.

(6) Snap ring - Snap ring pliers are used to spread snap rings as they are being installed or removed.

(7) Linemen's - Linemen's pliers are basically the same as side cutter pliers, except for being designed for heavier work.

(8) Adjustable channel lock - Adjustable channel lock pliers are similar to combination pliers except that they have more holding capacity due to jaw and slip joint design.

(9) Fence - Fence pliers can be used for pulling staples, cutting and stretching wire, and for light hammering.

Transparency No. 45

17. Selecting and Using Small Engine Repair Tools

a. Types and uses of small engine tools are:

(1) Ring compressor - The ring compressor is used to compress the rings when inserting the piston into the cylinder.

(2) Starter wrench - The starter wrench is used to remove or tighten the starter clutch.

(3) Flywheel holder - The flywheel holder secures the flywheel while removing or tightening the starter clutch.

(4) Flywheel puller - The flywheel puller is used to evenly apply pressure while removing the flywheel.

(5) Spring compressor - The spring compressor is used to remove and replace valve springs.

(6) Spark tester - The spark tester is used to check the ignition spark.

(7) Wire gauge - The wire gauge is used to check the spark plug gap.

Transparency No. 46

18. Selecting and Using Vises

a. Several thumb rules apply to the use of a vise. Some are as follows:

(1) Never use a hammer to loosen or tighten a vise. Use only the weight of the body.

(2) Select the vise according to the work to be done.

(3) With few exceptions, never hammer on vise jaws.

(4) Use soft metal or wood jaws to prevent marring finishes and slippage.

(5) Be sure that the vise is securely fastened.

b. The types of vises are:

(1) Machinist's
(2) General utility
(3) Pipe
(4) Blacksmith's
(5) Drill press
(6) Wood
(7) C-clamp (not actually a vise, and is more versatile and portable)

Transparency No. 47

19. Selecting and Using Concrete Tools

a. Types and uses of concrete tools are:

(1) Darby - The darby is used to eliminate ridges and voids caused by striking-off.

(2) Bull float - The bull float is used to eliminate ridges and voids caused by striking-off.

(3) Vibrator - The vibrator is used to make concrete a uniform mass.

(4) Strike-off board - The strike-off board is a 2 X 4 or 2 X 6 of the correct length used to even the surface by removing humps and hollows.

(5) Metal float - The metal float is used to remove imperfections and raise mortar to the surface.

(6) Wood float - The wood float is also used to remove imperfections and raise mortar to the surface.

(7) Metal trowel - The metal trowel is used to produce a smooth, dense surface.

(8) Power trowel - The power trowel is also used to produce a smooth, dense surface.

(9) Edger - The edger is used to round the edges and keeps them from breaking off.

(10) Jointer - The jointer or groover is used to control cracking of concrete caused by expansion and contraction.

(11) Jitterbug - The jitterbug is used make concrete a uniform mass.

Transparency No. 48

20. Selecting and Using Masonry Tools

a. Types and uses of masonry tools are:

(1) Level or Plumb Rule - These are available in either wood or metal and in lengths of 36 to 48 inches. The better quality levels have two level glasses at the center and two plumb glasses near each end.

(2) Trowels - The most used tool in masonry work is the trowel. Attention is directed to the difference in the shapes of the trowels in the above illustration. Better quality trowels are forged from a good grade of steel and hand ground to the proper shape, taper, and balance. Trowels of different lengths and widths may be purchased.

(3) Jointers - The mortar joints are finished with these tools. A 5/8 inch rod 24 inches long may also be used to finish the joints of concrete masonry units.

(4) Brick Set - This is a chisel-like tool used to cut brick and concrete masonry units. A brick layer's hammer is used to strike the set.

(5) Brick Hammer - The head is square and sharp and is used for splitting brick. A cut line is made around the brick by lightly tapping the brick with the head of the hammer. After the line is completed, a heavy blow is given to the center of the brick. Practice is required to get a clean cut. The blade of the hammer is used to trim the rough areas.

(6) Corner Blocks - These are used to hold the string in place and may be hand made or purchased.

(7) Electric Portable Saw - Electric saws are particularly useful when a large number of units need to be cut. Stationary masonry saws are also available.

21. Conditioning Hand Tools

Transparencies Nos. 49 and 50

a. Steps for jointing plane iron or chisel blade are listed below:

(1) Place the plane iron or chisel blade on the tool rest with the bevel pointing up.

(2) While holding the iron bevel on the tool rest, touch it very lightly against the wheel and move the iron from left to right until the nicks are removed.

(3) Check the edge for squareness.

b. Grinding a chisel blade or plane iron is accomplished in the following manner:

(1) Use a flat tool rest and adjust to proper angle for grinding the blade or iron at 25 to 30 degree angles.

(2) Grind the chisel blade to an angle slightly shorter or slightly longer than 1/4 inch, depending on the type of work to be done. A plane iron bevel is about 3/16 inch long.

(3) While grinding a blade or iron, lay it flat on the adjusted tool rest, and move it from side to side, keeping it perpendicular to the face of the wheel. Grind until a wire edge appears on the flat side.

(4) Dip the blade or iron in water occasionally to keep it cool.

(5) Check the blade or iron frequently for squareness by using a try square; use a template to determine the correct angle of the bevel. The angle (25 degrees) can be obtained by setting a T-bevel on the numbers 3 and 6 of a carpenter's square.

c. Hone the blade or iron by using the following steps:

(1) Put the final finish on the cutting edge by honing it on an oilstone. Use a few drops of oil before laying the flat side of the blade on the oilstone to help remove the wire edge; reverse the position and hone the angle until the wire edge disappears.

(2) After the wire edge is removed, the bevel is placed against the oilstone. To adjust the desired angle, rock the blade or iron back and forth until the angle is flat on the oilstone surface.

(3) Move the plane iron or chisel blade in a back-and-forth motion with both hands moving parallel to the stone. Keep the oilstone surface moist with oil to prevent the fine steel particles from entering the stone's pores.

(4) Round the plane iron edges by honing. This step is not required when honing a chisel blade.

Transparency No. 51

d. Reconditioning auger bits is done in the following manner:

(1) Straighten the cutting spurs if they are bent inward or outward. The spurs can be placed in a piece of thin flat metal and tapped lightly with a hammer.

(2) Hold the bit at a slight angle while filing the lips. Both lips should be filed at about a 25 degree angle. The lips and spurs are filed only on

one side or surface, except for removing a wire edge that may be formed on the unfiled side.

(3) Remove rust from the twist by oiling the entire bit, and polish the twist by pulling a piece of small rope through it. The outside flat surface of the twist can be cleaned by wiping it with an oily rag.

(4) Some shops do not have the bit file; therefore, a small slim taper three-cornered file may be used to sharpen a bit if the individual is careful. A standard grinding wheel should not be used to reshape auger bits.

Transparency No. 52

e. The important steps to follow in sharpening a twist drill are:

(1) Place the drill point against the grinder wheel (both point and shank at the same height). Use both hands if possible. The drill should be held at a 60 degree angle to the wheel.

(2) Use one hand near the bit point and wheel; raise the bit cutting point and at the same time lower the shank with the other hand during the grinding process.

(3) Make slow strokes as the point is pushed against the grinder wheel. The drill bit should be slightly rotated clockwise as the point is forced on an upward sweep. Dip the bit point in water at frequent intervals while it is being ground to keep it from overheating.

(4) Rotate the drill and grind the other lip in the same manner.

(5) Use a template to check the proper angle after every few strokes. Also, check for a 12 degree clearance from the front of the cutting lip to the back edge (heel).

Transparency No. 53

f. The steps in reconditioning screwdriver tips are:

(1) Joint the end square by holding the tip at a 90 degree angle against the grinding wheel.

(2) Shape both faces of the screwdriver by placing them high on the grinding wheel. Carefully push and pull the handle with one hand as the other hand helps guide the tip. Only light pressure is applied during the time the the blade is in contact with the grinding wheel.

(3) Dip the blade in water several times during the grinding process to cool. Use a screw head to determine the extent of grinding desired.

(4) Grind both sides of the tip in the same manner as grinding the faces. The tip should be placed in a screw slot during the shaping process in order to make it the same width as the screw head. The sides may be shaped parallel 1/4 inch from the tip.

(5) Final shaping of a tip may be accomplished by using a file or oilstone.

(6) If a screwdriver tip has been twisted, it may be reshaped by placing it on an anvil and tapping the twisted part with a ball peen hammer.

Transparency No. 54

g. The steps in reconditioning cold chisels are:

(1) Joint the cutting edge until all nicks or gaps are removed. Hold the chisel in a level position while moving the point from side to side across the stone.

(2) Hold the handle part of the chisel with one hand and place the chisel body against the tool rest at about 65 to 70 degree angle with the handle pointing down.

(3) Use the fingers or thumb of the other hand to apply pressure and help guide the point from side to side on the wheel. A slight swing of the chisel handle will give the chisel a curved cutting edge. Dip the point in water frequently while grinding it to keep it cool.

(4) Grind both sides of the cutting edge in the same manner.

(5) Check for the desired angle of bevel. The angle should be checked during the process of grinding both bevels. An angle gauge may be determined by cutting a V 3/8 inch deep and 1/2 inch wide in a piece of thin metal. This template will have two 70 degree sides.

(6) If a mushroom head is formed on the chisel, grind it off at the same time the chisel is being sharpened. Pieces of flying steel from the head may cause accidents.

(7) If the chisel is ground to the point that it is too thick at the end, it may be necessary to heat the chisel, draw it out, and retemper the cutting point.

References:

1. Durbahn, Walter E., Fundamentals of Carpentry Tools, Materials, and Practices, American Technical Society, Chicago, Illinois, 1971.

2. McDonnell, Leo P., Hand Woodworking Tools, Delmar Publishers, Albany, New York, 1962.

3. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1978.

4. Wakeman, T. J., Modern Agricultural Mechanics, The Interstate Printers and Publishers, Danville, Illinois, 1977.

5. "Concrete Technology", Delmar Publishers, Albany, New York, 1965.

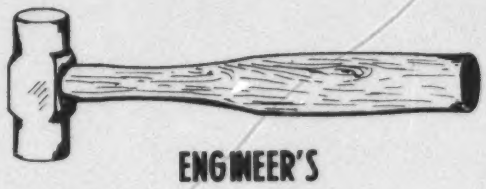
6. "Fundamentals of Service-Shop Tools", Deere and Company, Moline, Illinois, 1973.

7. "Recommended Practices for Building with Concrete Masonry", Vocational Agriculture Service, University of Illinois, Urbana, Illinois, 1972.

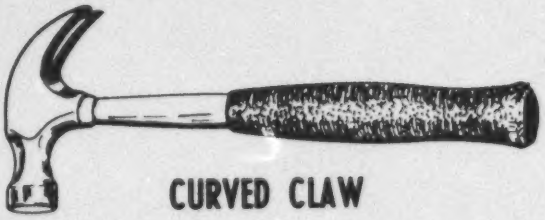
8. "Service and Repair Instructions", Briggs and Stratton Corp., Milwaukee, Wisconsin, 1977.

TYPES OF HAMMERS

RIPPING CLAW



ENGINEER'S



CURVED CLAW

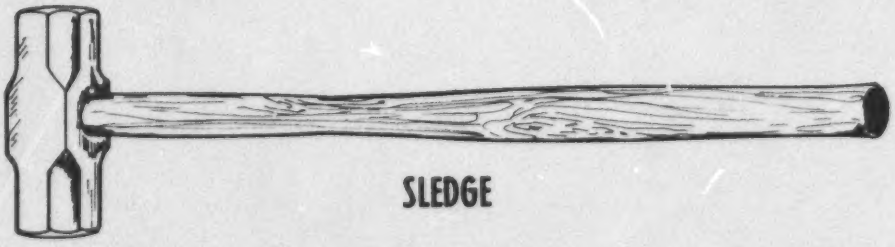
BALL-PEEN or MACHINIST'S

MACHINIST'S RIVETING

SOFT-FACE PLASTIC

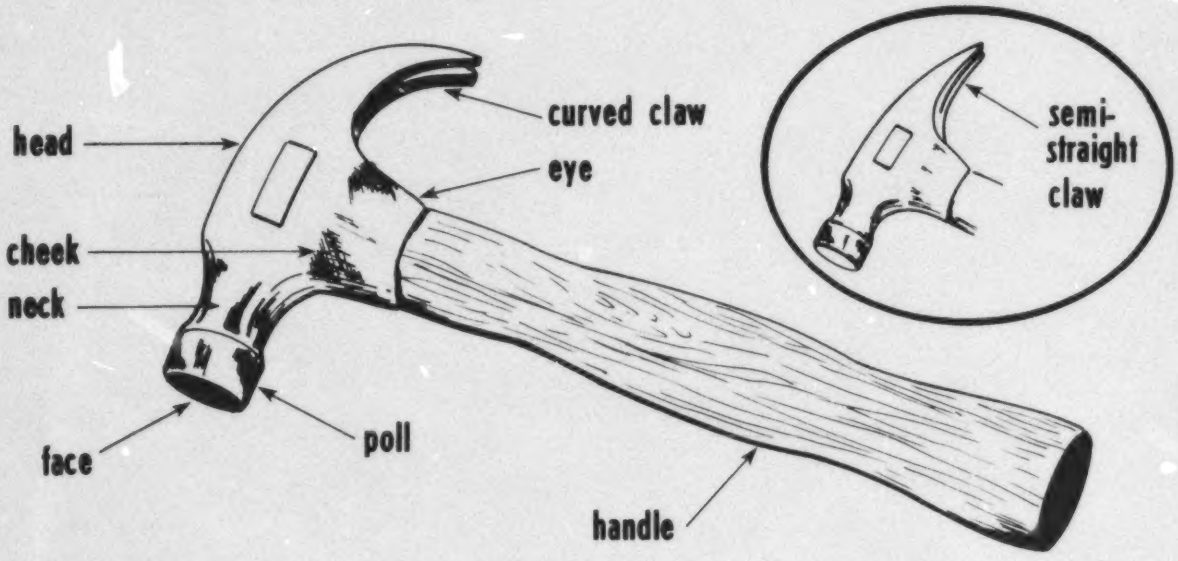
BLACKSMITH'S

SOFT-FACE RUBBER

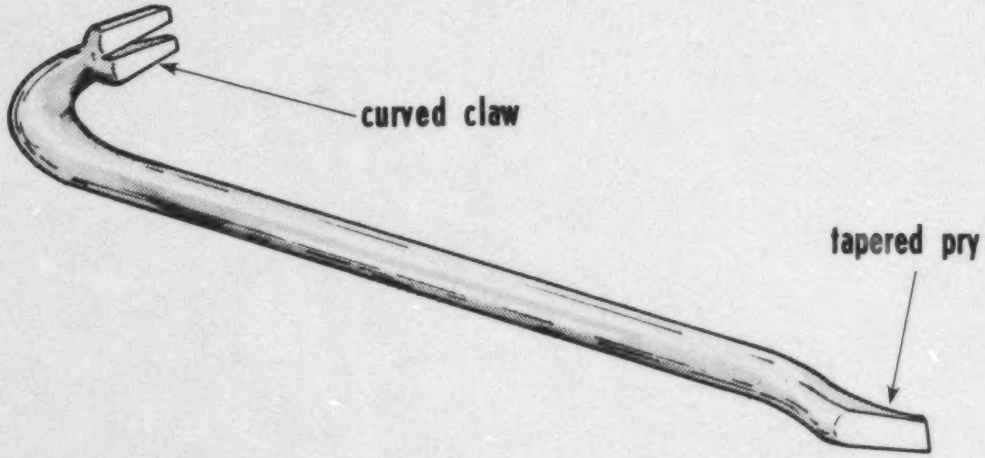


SLEDGE

PARTS OF A CLAW HAMMER

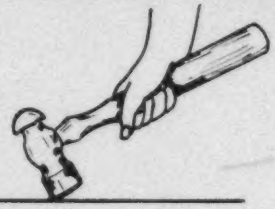


PARTS OF A WRECKING BAR



USING HAMMERS

WRONG



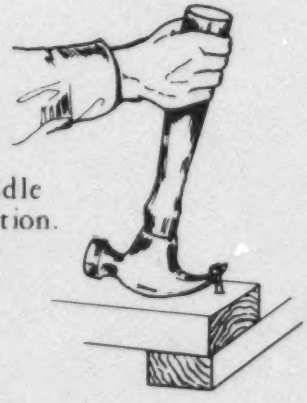
RIGHT

The face of the hammer should be flat in relation to the surface.

Grasp handle near end.

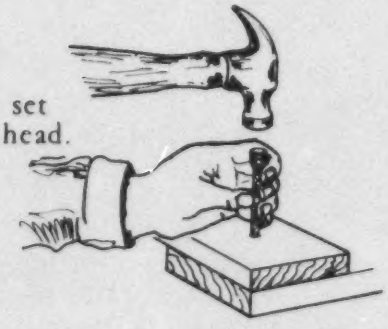
Use finger & thumb to hold nail.

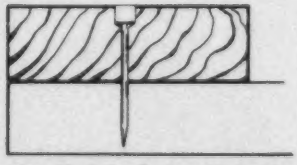
First-Raise handle to vertical position.



Finish pulling nail with block.

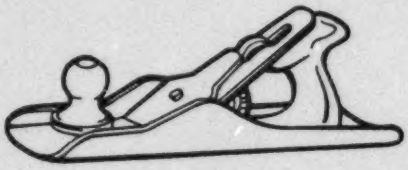
Use nail set to sink nail head.



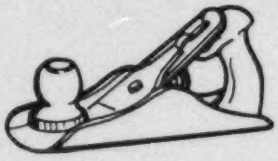


Nail head set 1/16" below surface.

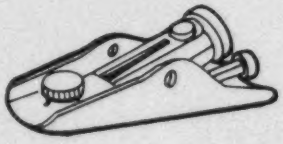
TYPES OF HAND PLANES



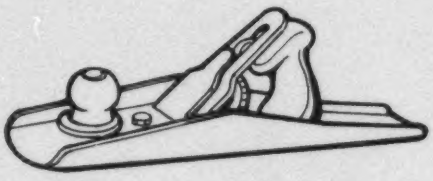
JACK
(11½-15 inches long)



SMOOTH
(5½-10 inches long)

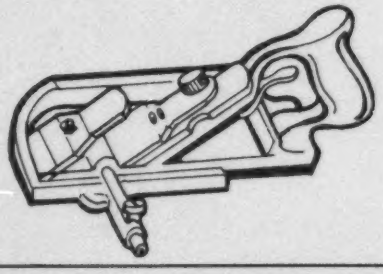


BLOCK
(average length - 6 inches)



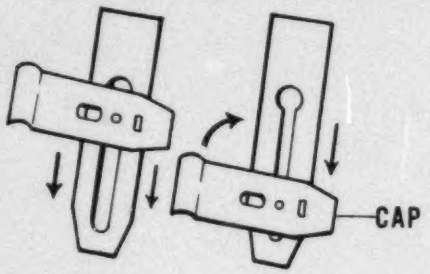
JOINTER
(22-24 inches long)

FORE
(18 inches long)

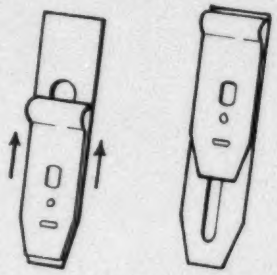


RABBET
(average length - 8 inches)

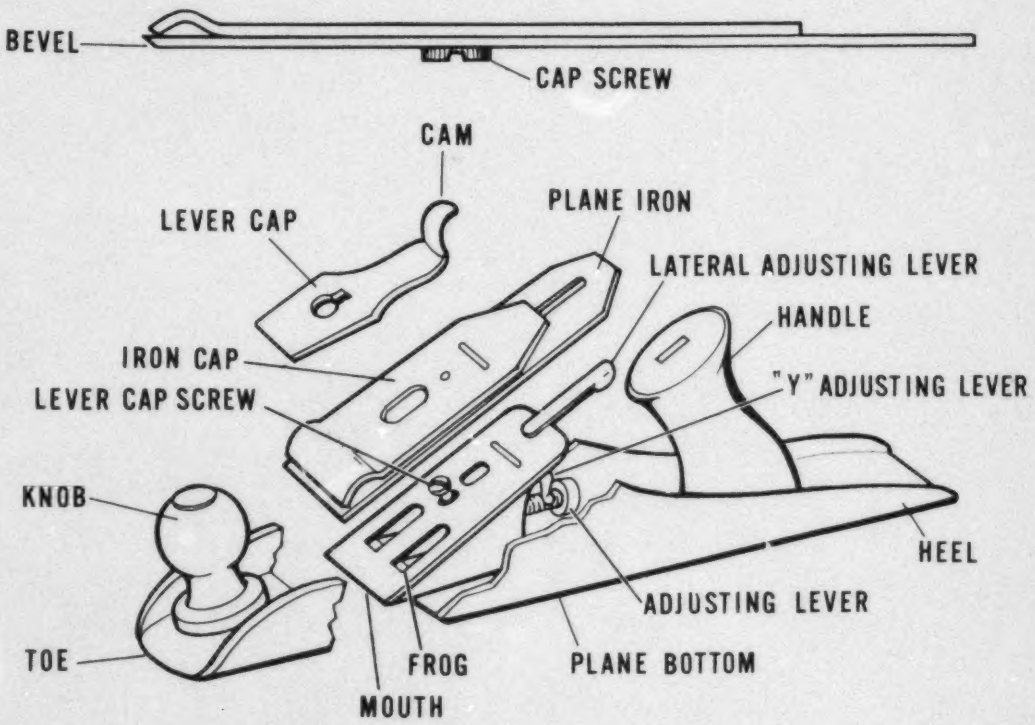
ADJUSTING IRON & PARTS OF PLANE



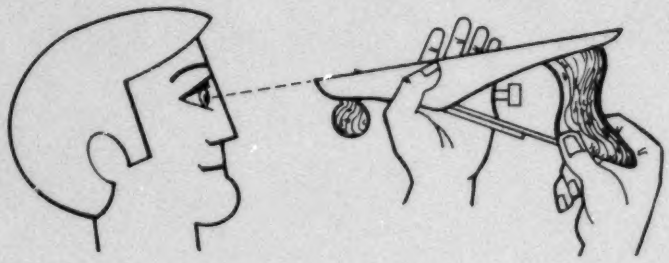
Turn plane iron cap to the right. It passes back of cutting edge.



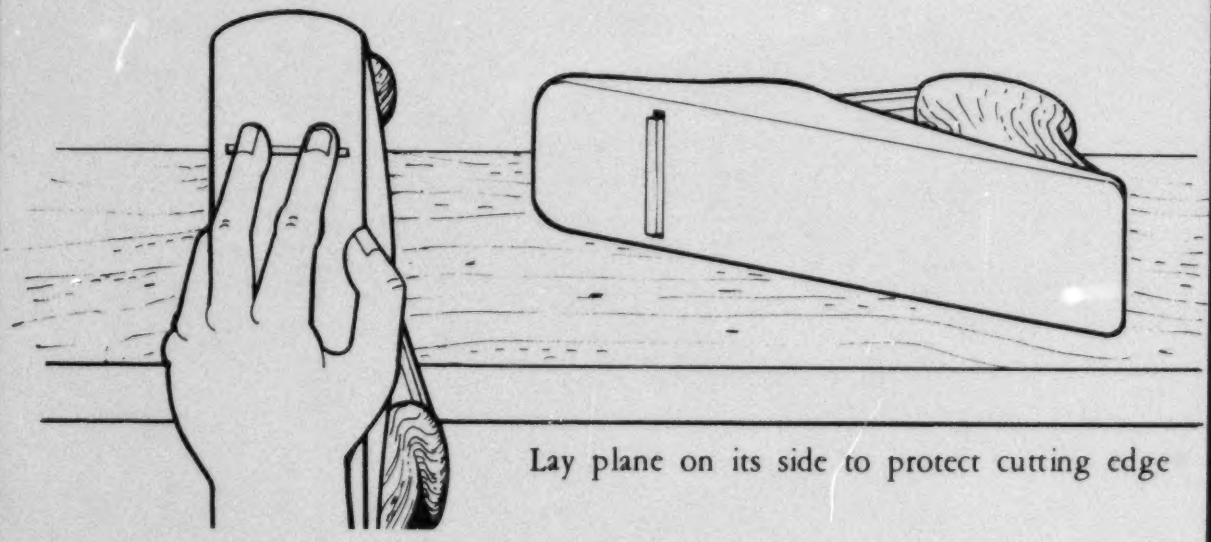
Slide plane iron cap to within 1/32 in. to 1/64 in. of blade edge.



PLANE ADJUSTMENT & CARE



Adjustment of blade to cut evenly can be made by sighting across plane

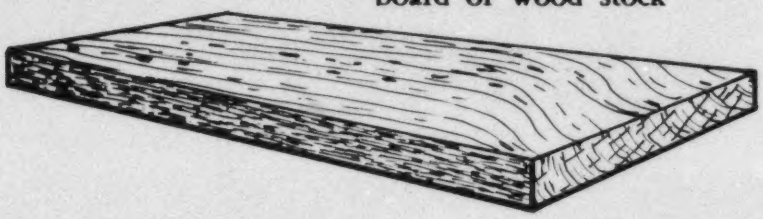


Lay plane on its side to protect cutting edge

Check blade setting by the feel of two fingers

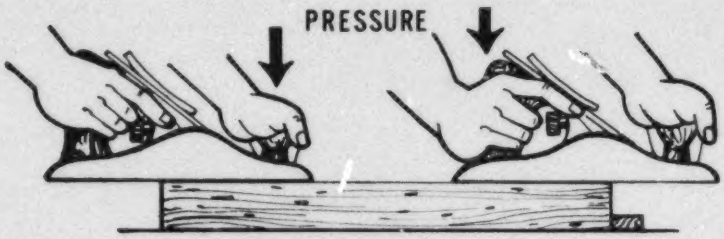
USE OF THE HAND PLANE

board or wood stock

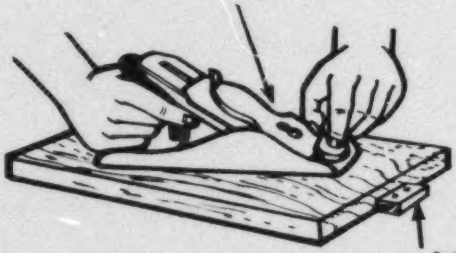


Pressure is on knob at start

Pressure is on handle at finish

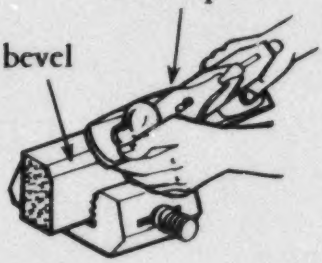


Plane with grain



block plane

bevel

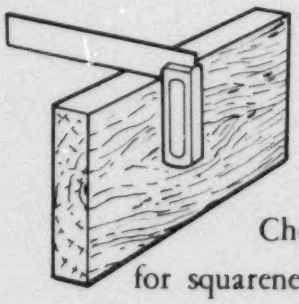


Pressure is equalized on handle & knob

HAND PLANE USE & CHECKING PLANED WOOD

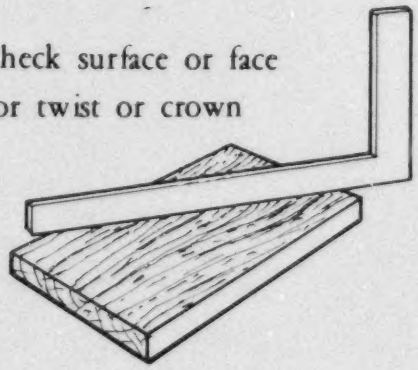
When planing end grain plane to center from each side

Hold plane at angle
when planing end

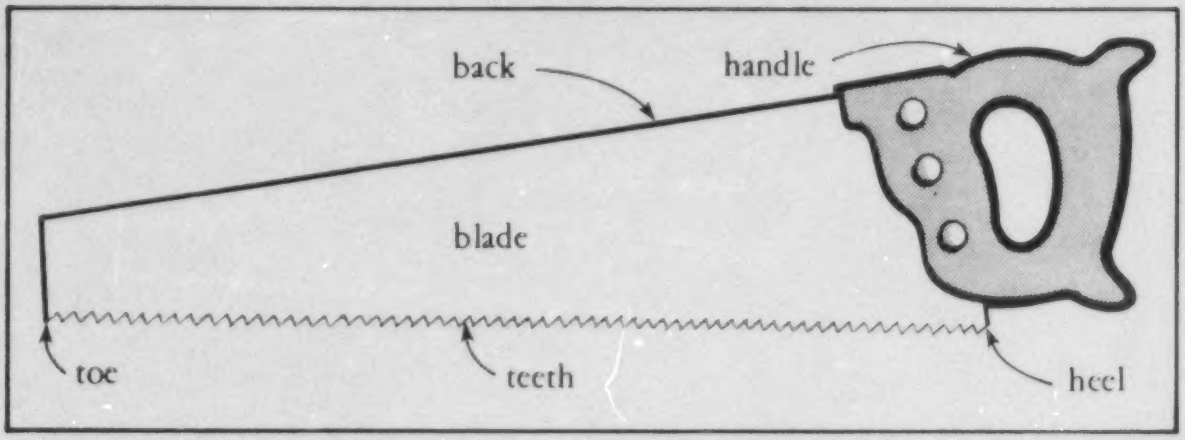


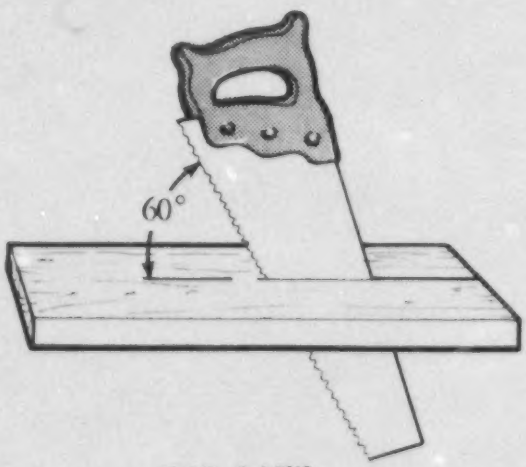
Check edge & face
for squareness while planing

Check surface or face
for twist or crown

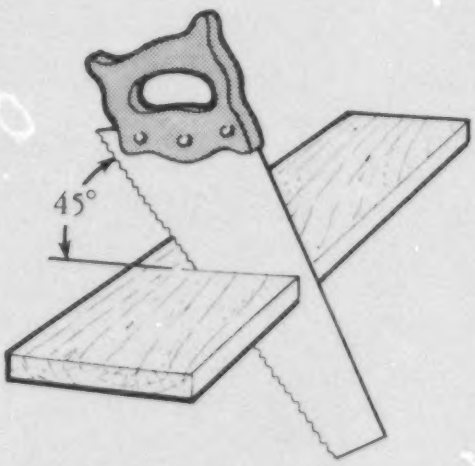


HAND SAWS



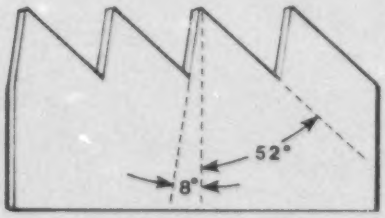


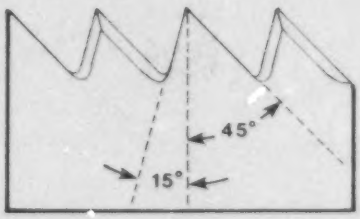
RIP SAW



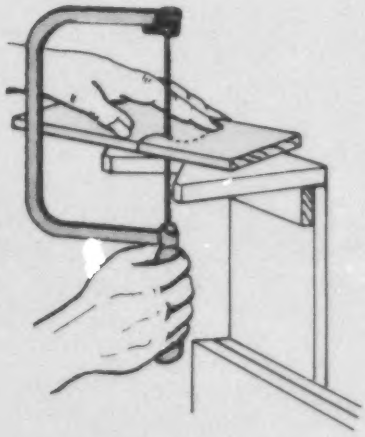
CROSSCUT SAW

SAW TEETH

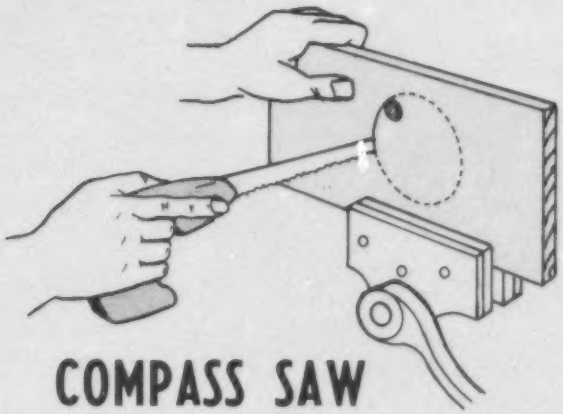




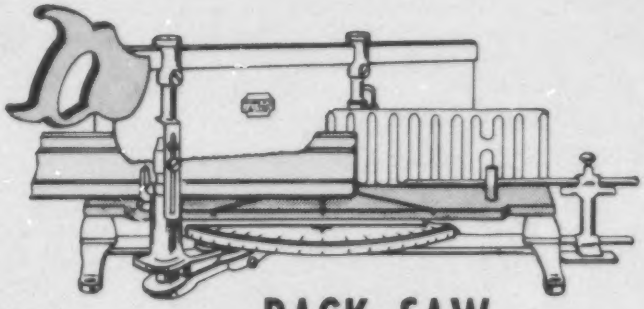
HAND SAWS



COPING SAW



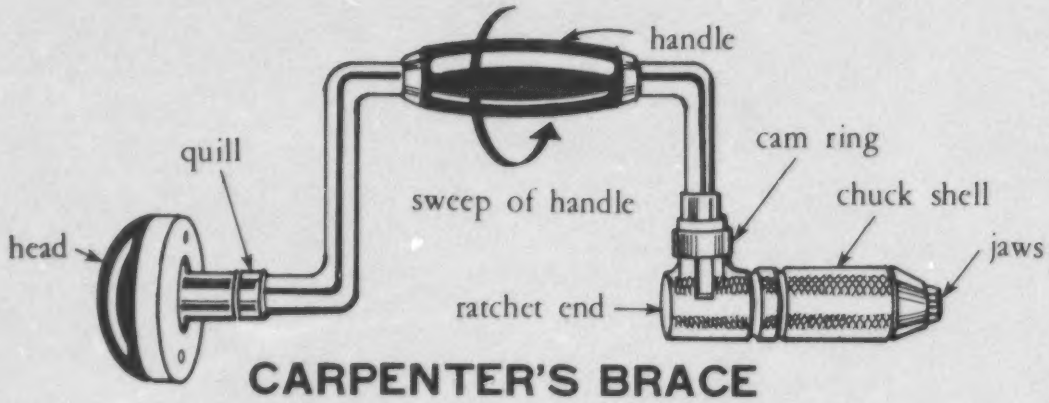
COMPASS SAW



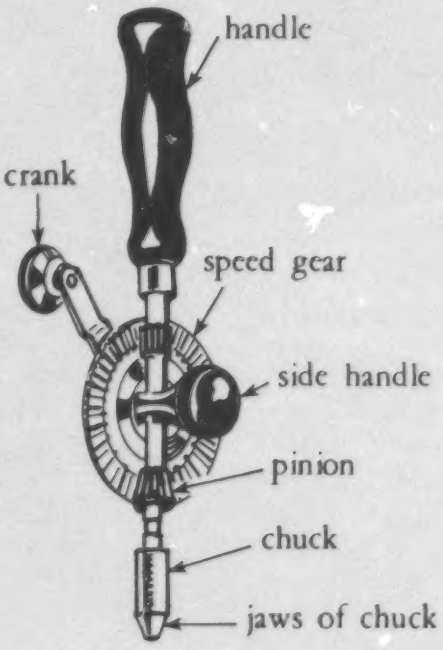
BACK SAW
& MITER BOX

HACKSAW

TYPES OF DRILLS

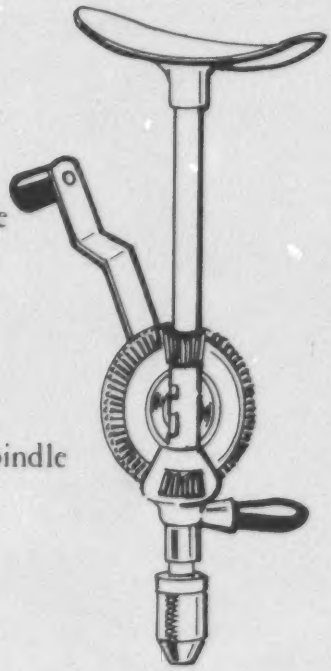


CARPENTER'S BRACE

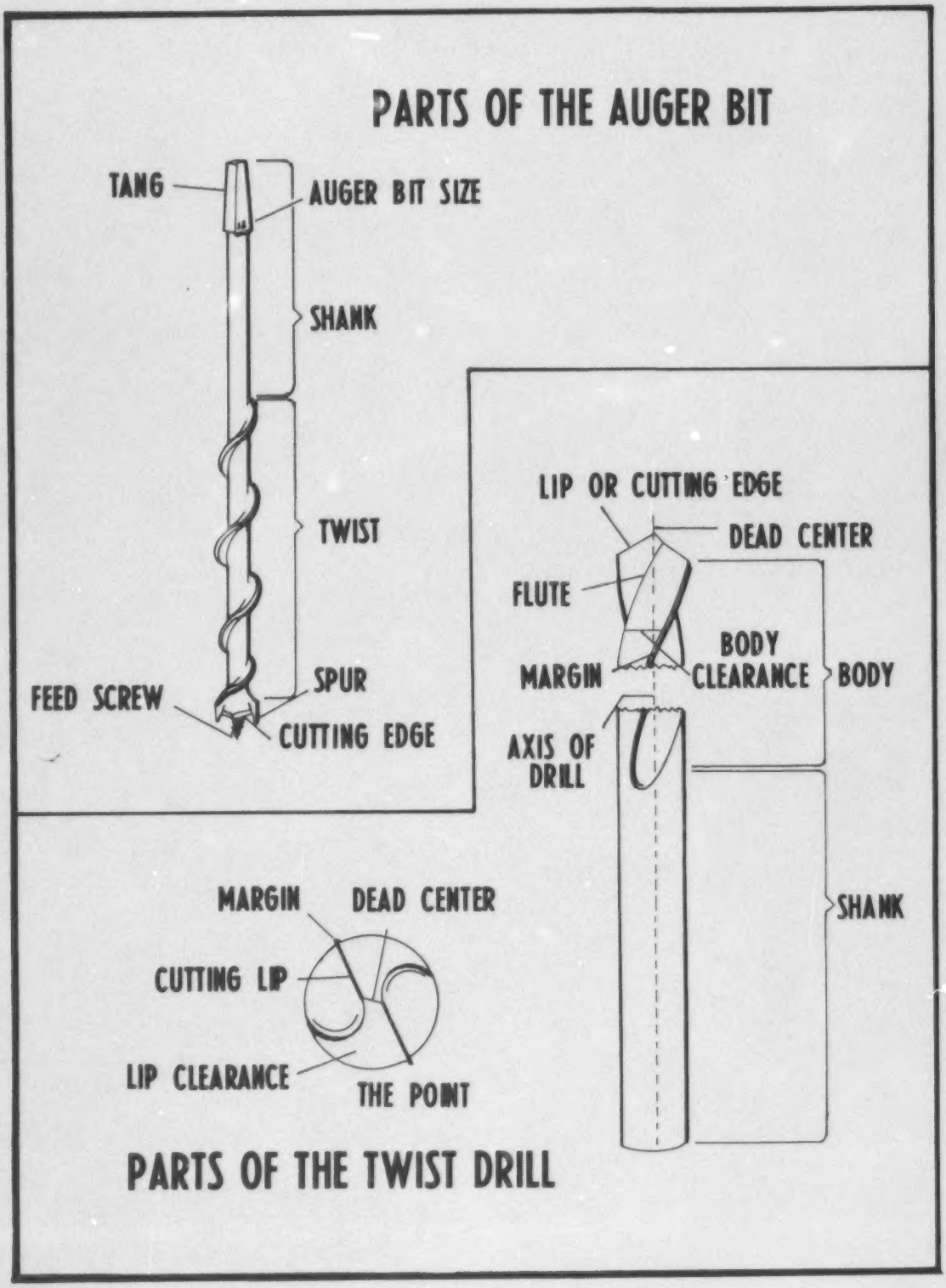


HAND

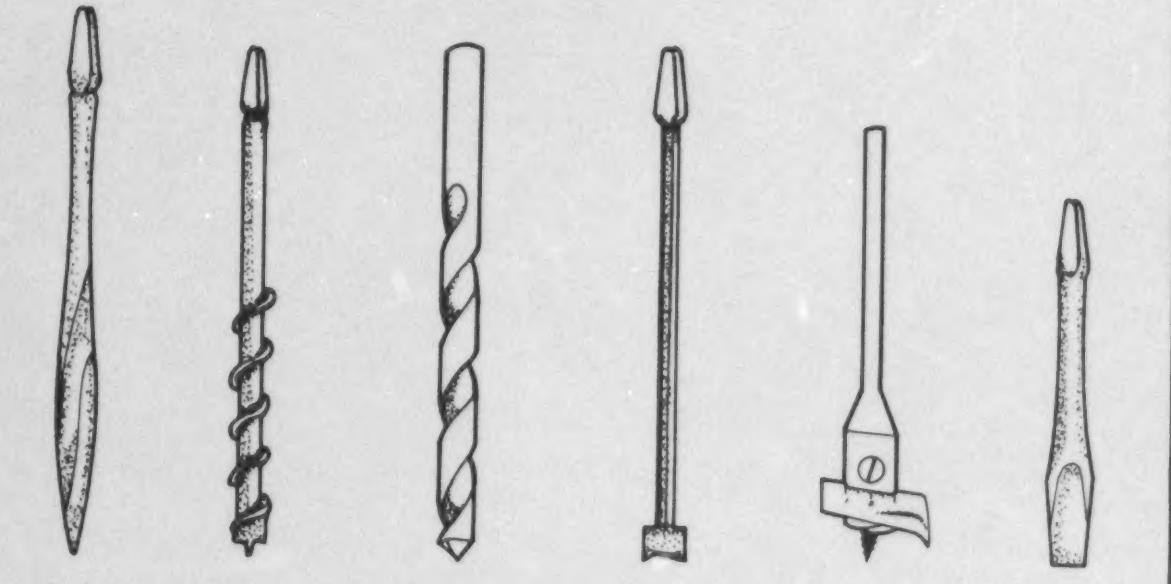
PUSH



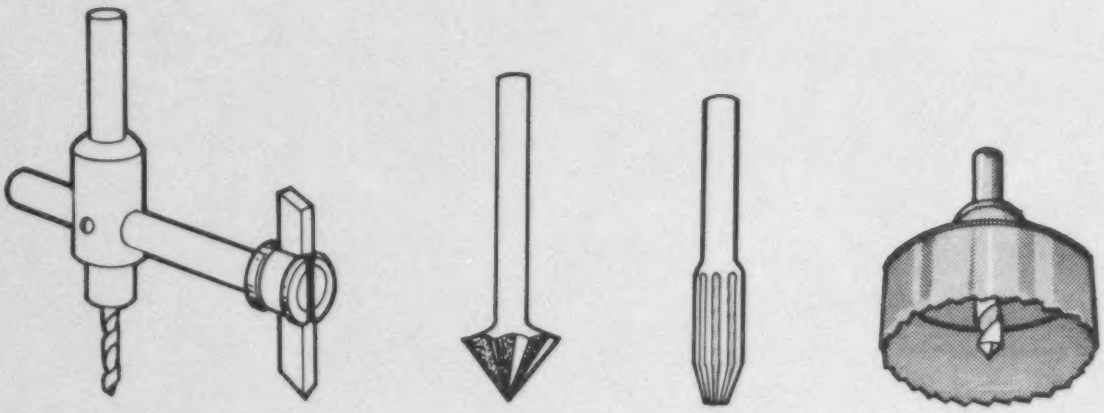
BREAST


PARTS OF THE AUGER BIT
TANG
AUGER BIT SIZE
SHANK
TWIST
SPUR
FEED SCREW
CUTTING EDGE
LIP OR CUTTING EDGE
DEAD CENTER
FLUTE
BODY
MARGIN
CLEARANCE
BODY
AXIS OF
DRILL
SHANK
MARGIN
DEAD CENTER
CUTTING LIP
LIP CLEARANCE
THE POINT
PARTS OF THE TWIST DRILL

TYPES OF BITS



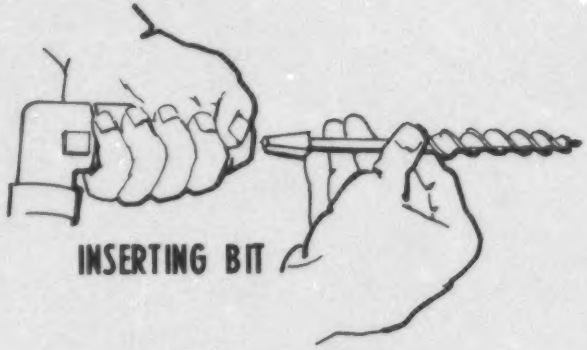
gimlet auger twist forstner expansive screw driver



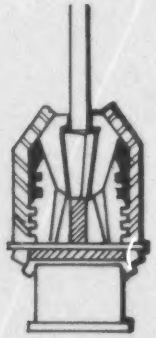
circle cutter countersink reamer multi-spur

PLACING THE BIT IN THE BRACE

OPENING JAWS

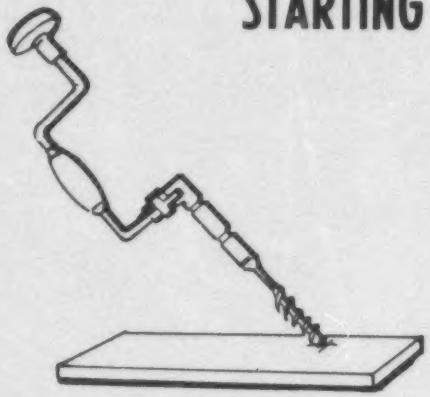


INSERTING BIT

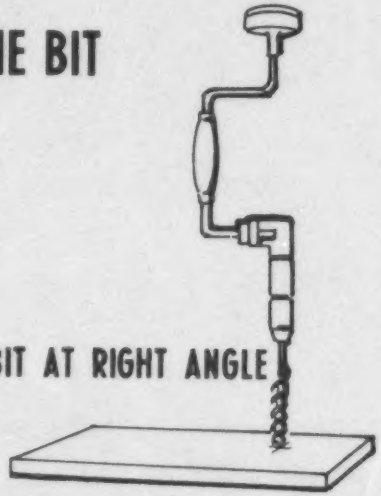


BIT FIRM IN JAWS

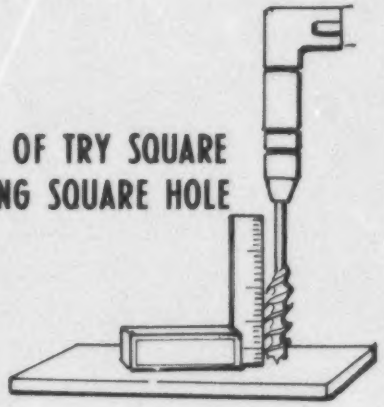
STARTING THE BIT



POINT OF BIT AT CROSS MARKS



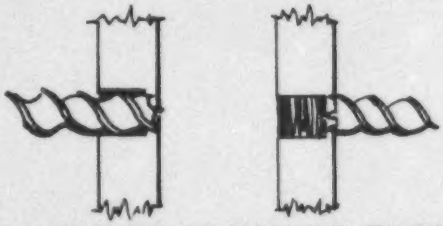
BIT AT RIGHT ANGLE



USE OF TRY SQUARE
BORING SQUARE HOLE

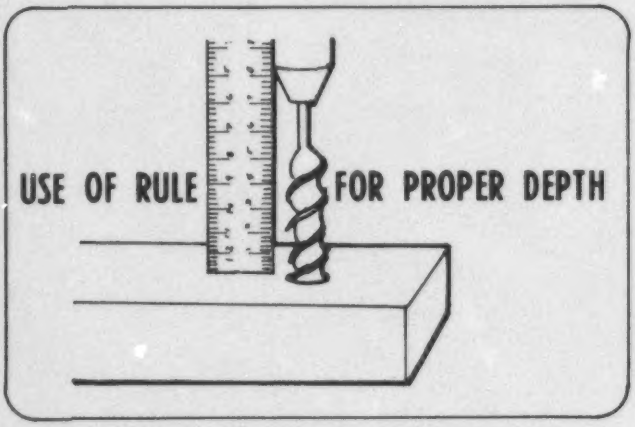
BORING A HOLE THROUGH A BOARD

APPLY CORRECT PRESSURE

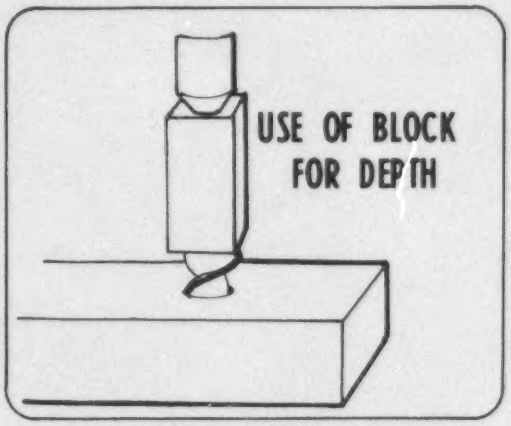


REVERSING BIT TO PREVENT SPLINTERING

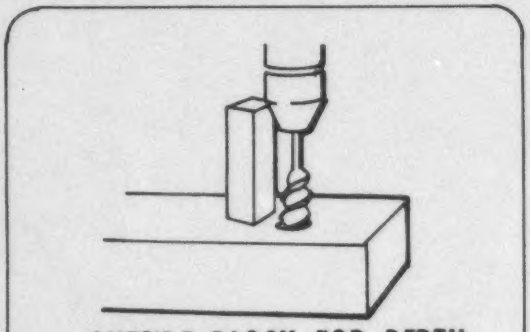
DETERMINING DESIRED DEPTH



USE OF RULE FOR PROPER DEPTH

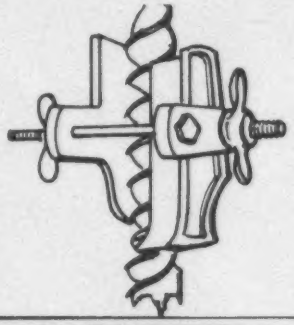


USE OF BLOCK FOR DEPTH



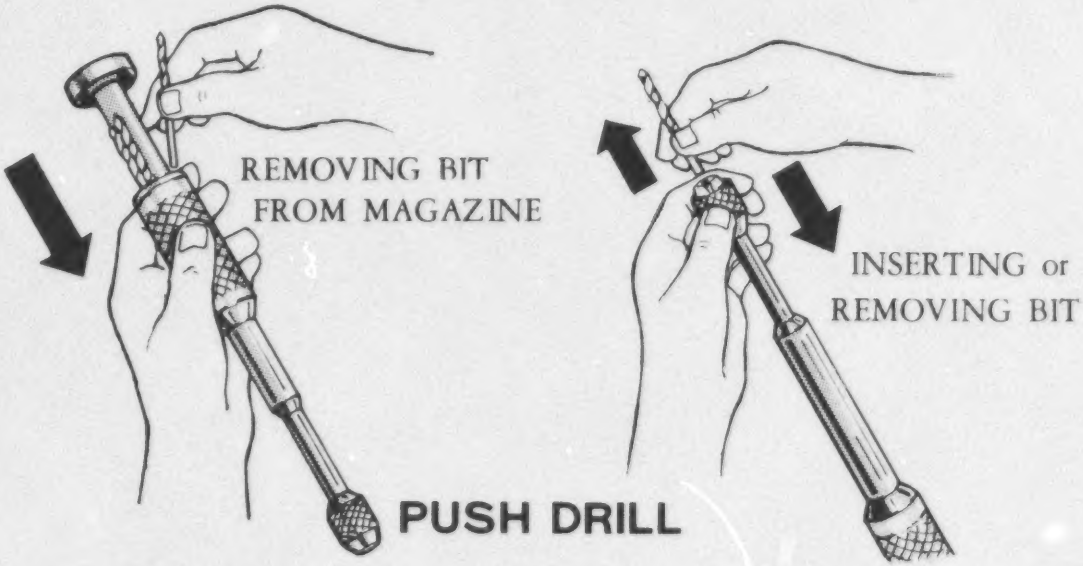
OUTSIDE BLOCK FOR DEPTH

USE OF DEPTH GAUGE



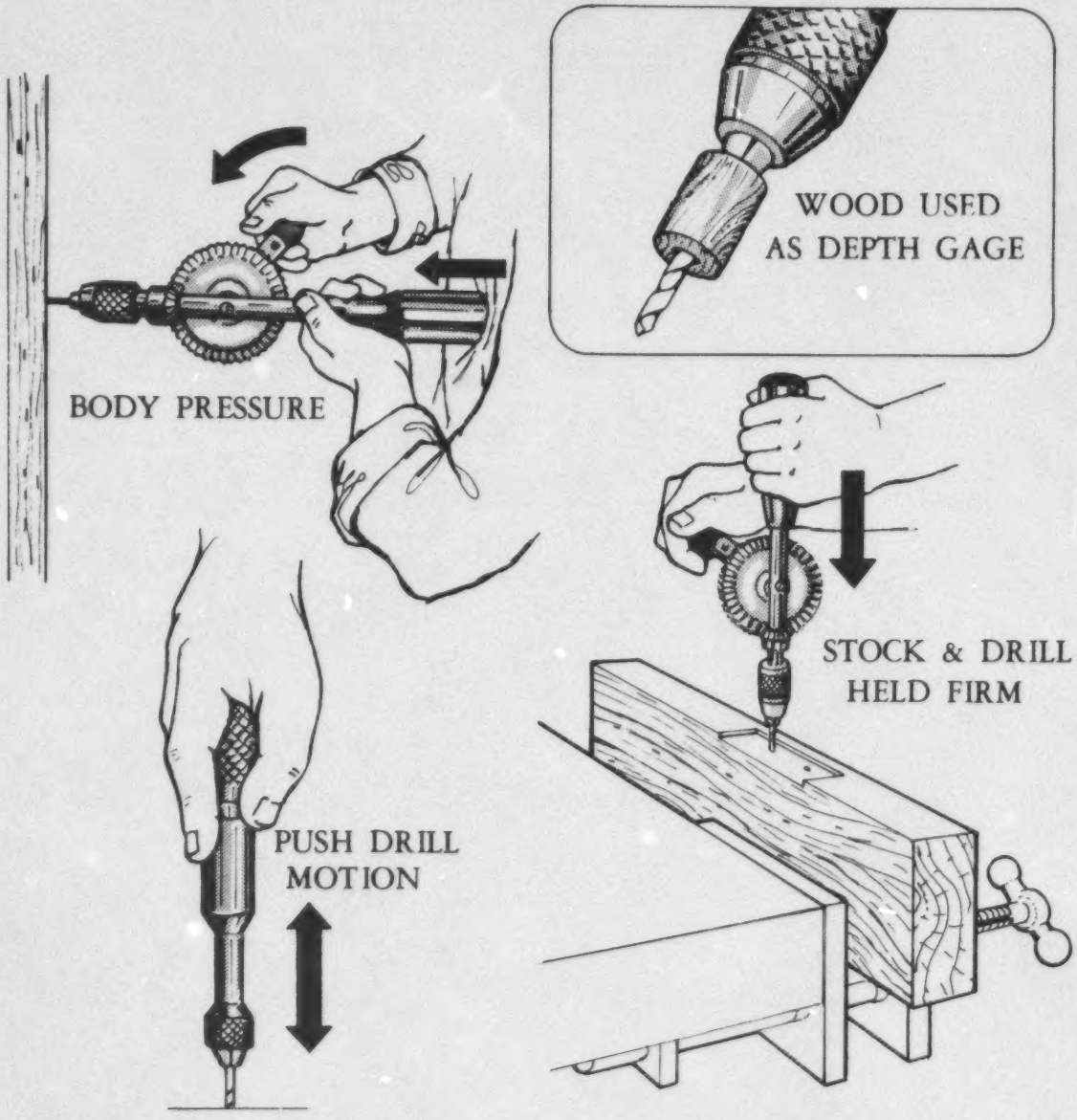
INSERTING & REMOVING DRILL BITS

HAND DRILL



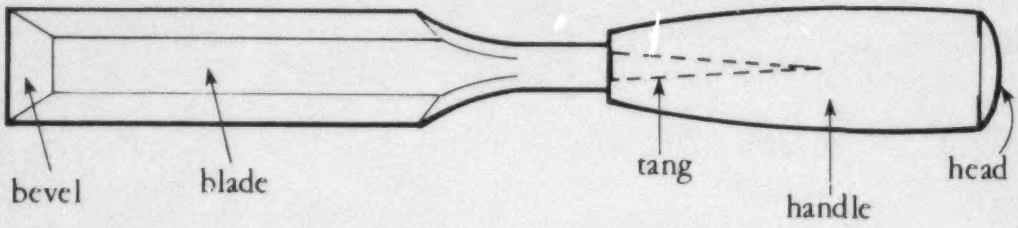
PUSH DRILL

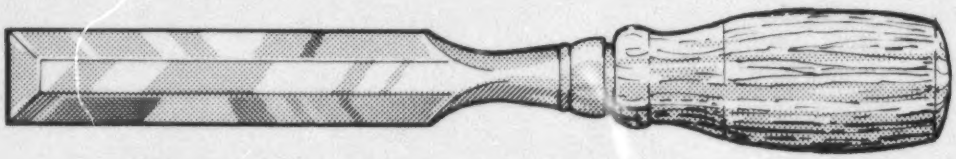
USE OF HAND DRILLS



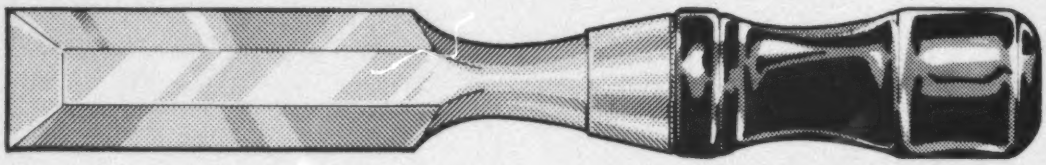
PARTS & TYPES OF WOOD CHISELS

PARTS of a WOOD CHISEL

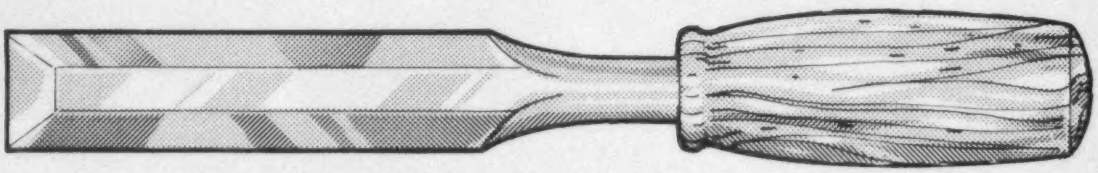




SOCKET CHISEL (wood handle)

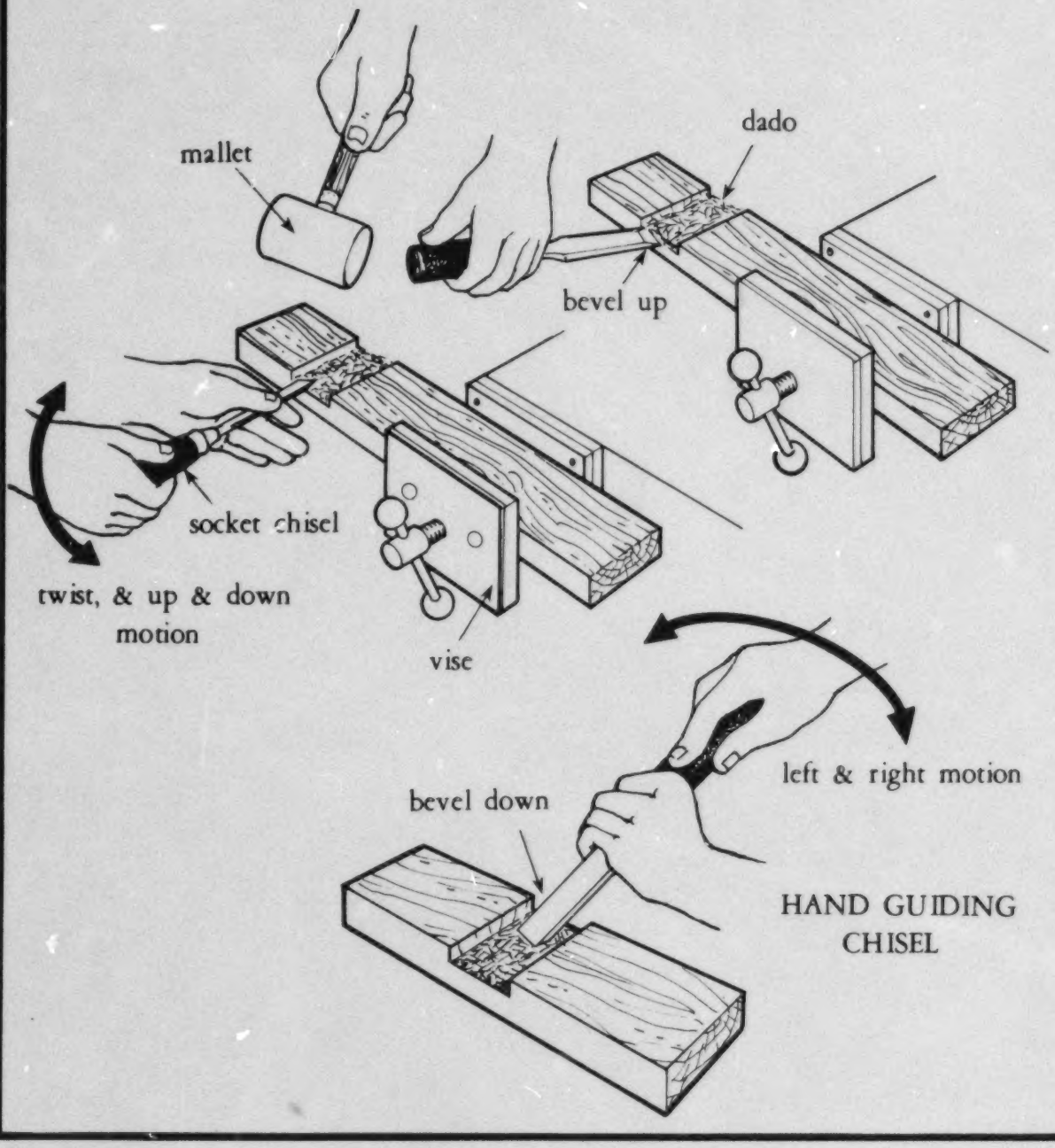


SOCKET CHISEL (plastic handle)



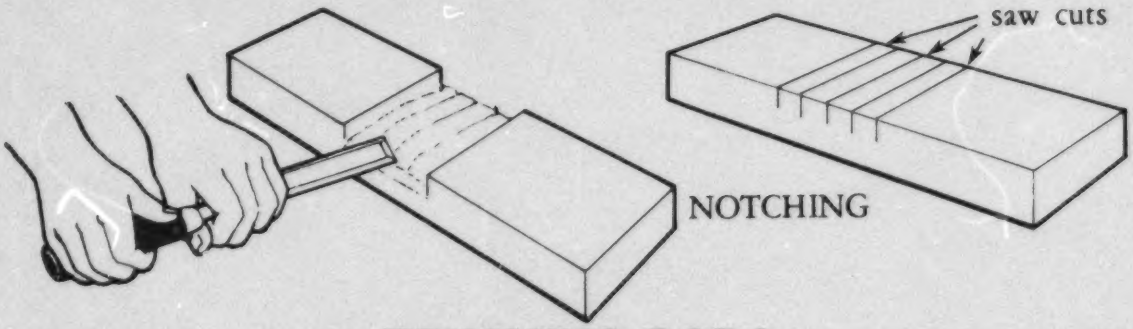
TANG CHISEL

STEPS IN CUTTING WITH CHISEL

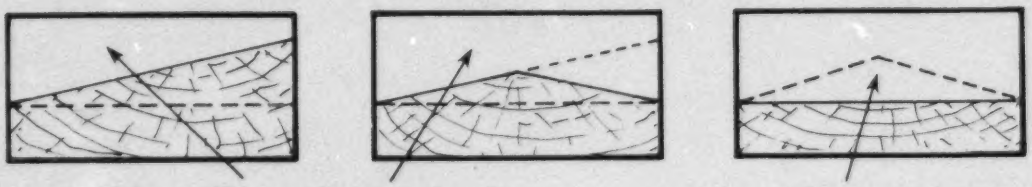


HAND GUIDING
CHISEL

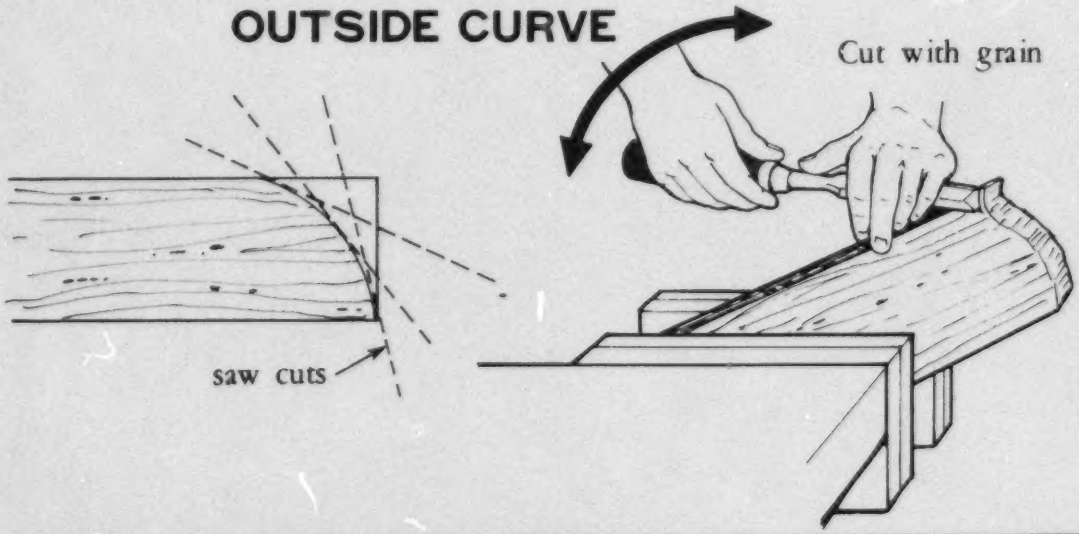
DADO, NOTCHING, & CURVE CUTTING



TRIMMING DADO



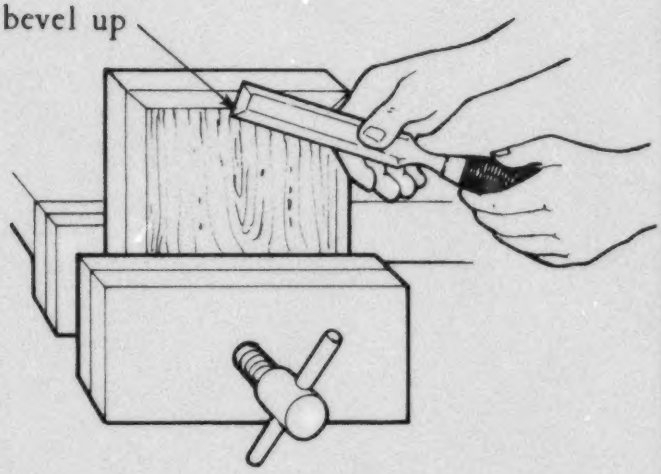
OUTSIDE CURVE



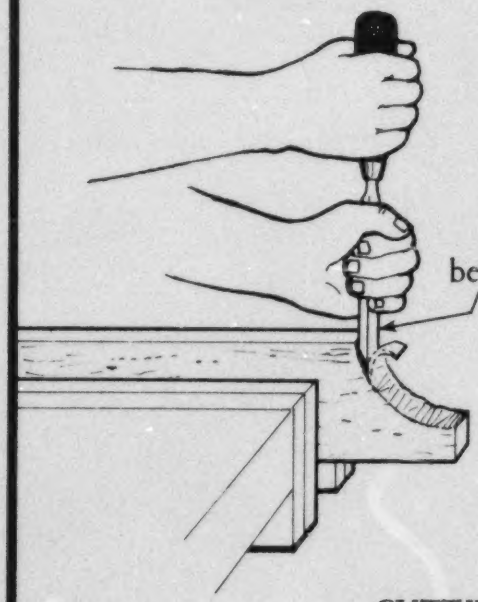
INSIDE CURVE, PARING & MORTISE-AND-TENON

PARING CHAMFERS

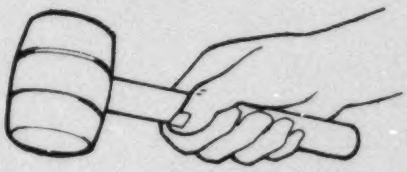
bevel up

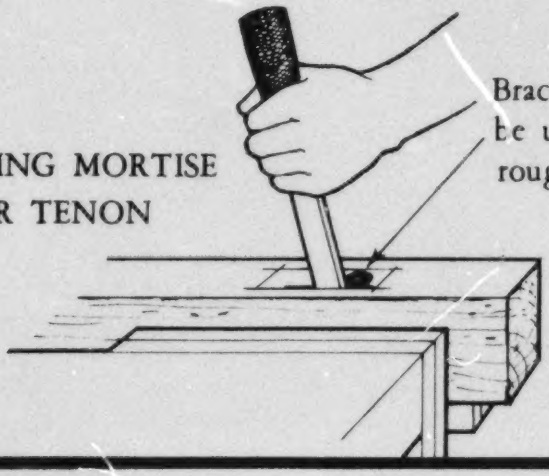


CUTTING INSIDE CURVE



bevel down

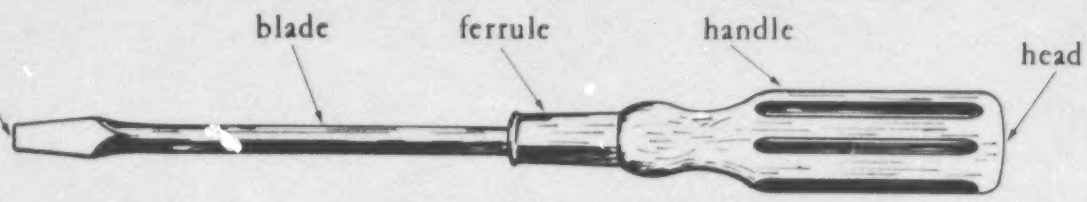




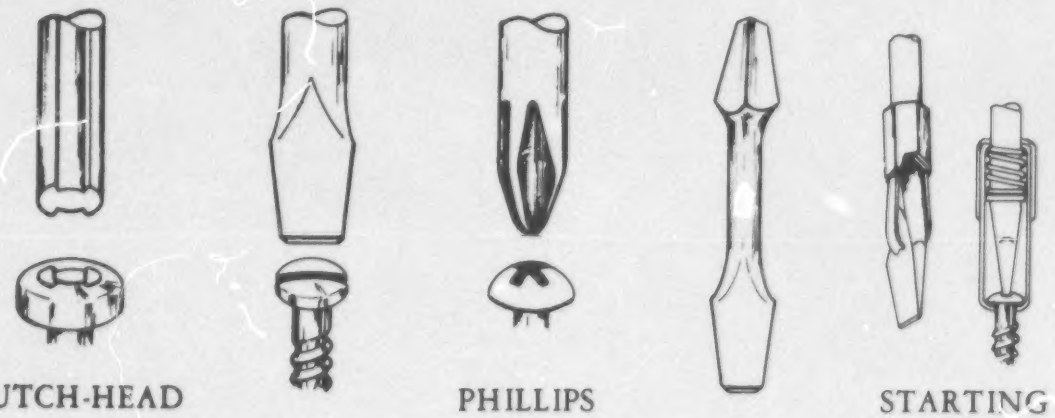
Brace & bit can be used to make rough cut

CUTTING MORTISE FOR TENON

TYPES OF SCREWDRIVERS



PARTS OF A SCREWDRIVER



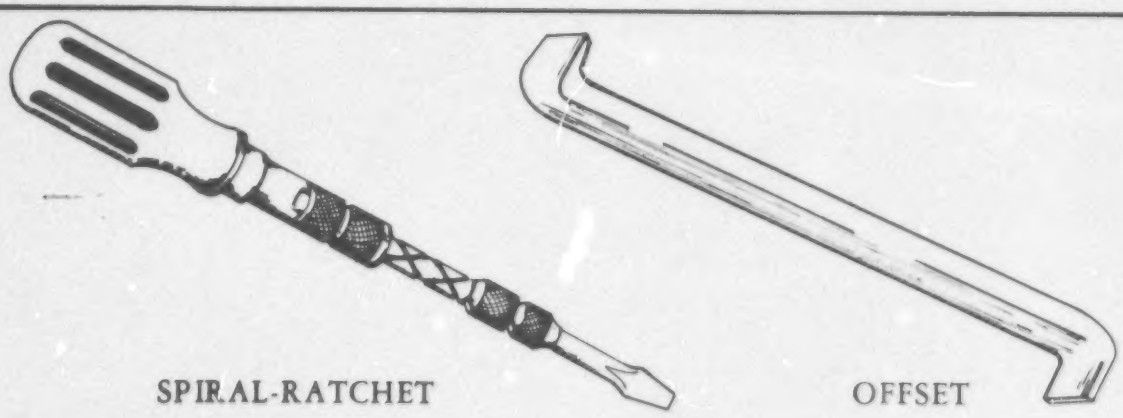
CLUTCH-HEAD

STANDARD

PHILLIPS

SCREWDRIVER BIT

STARTING



SPIRAL-RATCHET

OFFSET

SELECTING THE SCREWDRIVER

Correct Tip (square)

Incorrect Tip (curved)

Correct Size

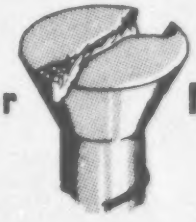
Incorrect Size (too small)

Correct Size
Phillips Tip

Correct Width

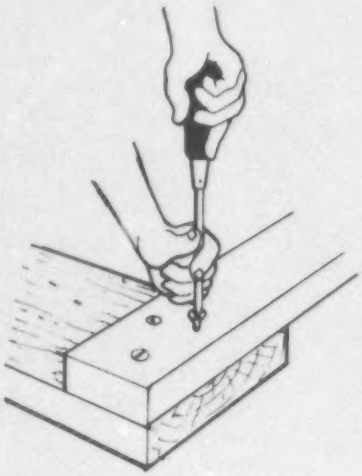
Incorrect Width (too wide)

Use of Incorrect Screwdriver

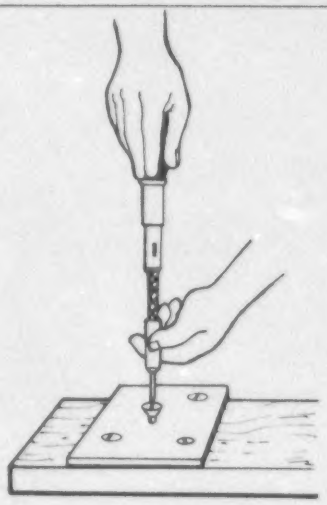


Results in Marred Screw Head

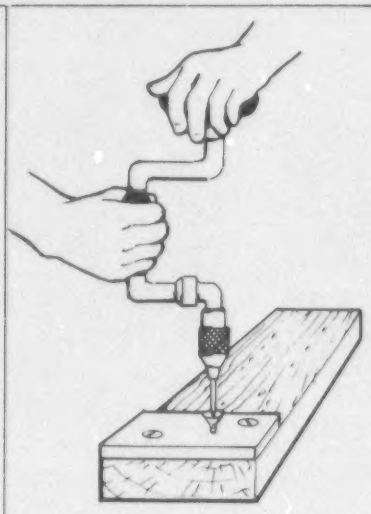
USE OF SCREWDRIVER



Proper position of hands for a standard & Phillips

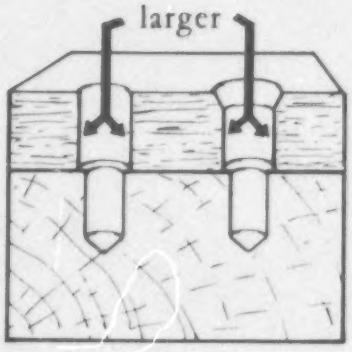


Proper position of hands for a ratchet

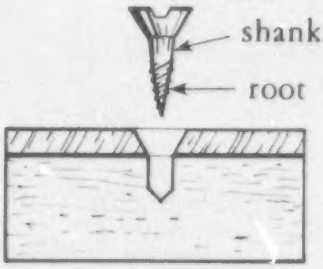


Proper position of hands for a brace & screwdriver bit

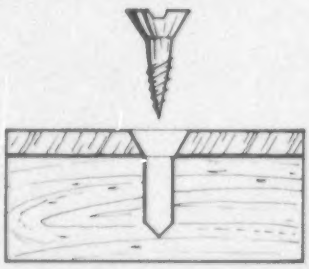
FASTENING WOOD TO WOOD



FASTENING METAL TO WOOD

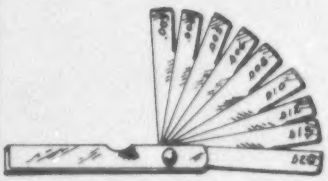


Hole for soft wood (½ thread distance)

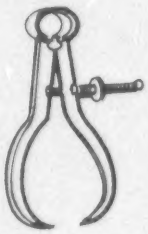


Hole for hardwood (full length of screw)

TYPES OF MEASURING TOOLS

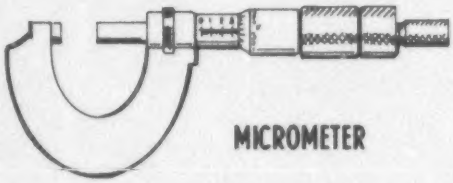


FEELER GAUGE

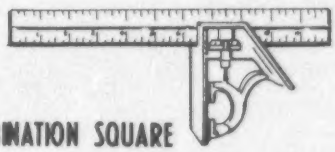


OUTSIDE CALIPER

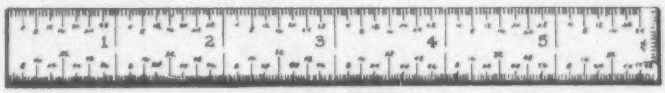
INSIDE CALIPER



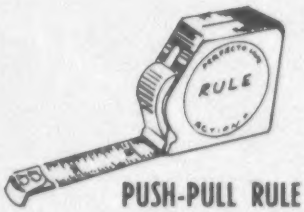
MICROMETER



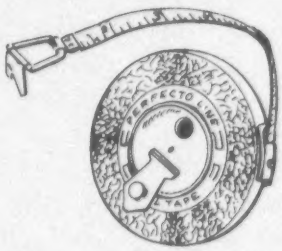
COMBINATION SQUARE



STEEL RULE

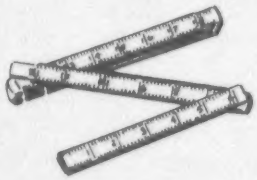


PUSH-PULL RULE

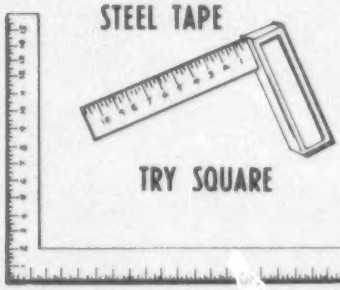


STEEL TAPE

MARKING GAUGE



FOLDING EXTENSION RULE

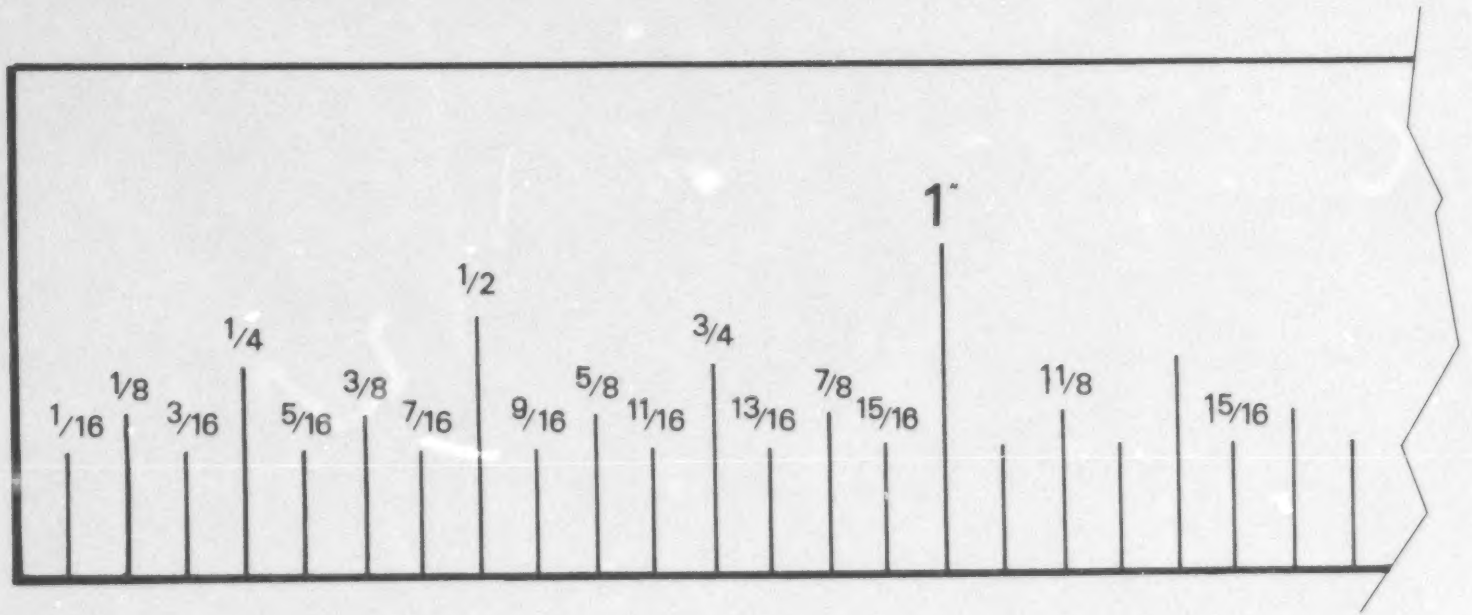


TRY SQUARE

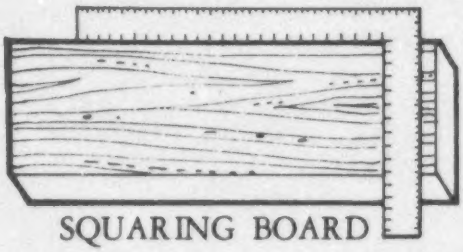
T-BEVEL SQUARE

CARPENTER'S FRAMING SQUARE

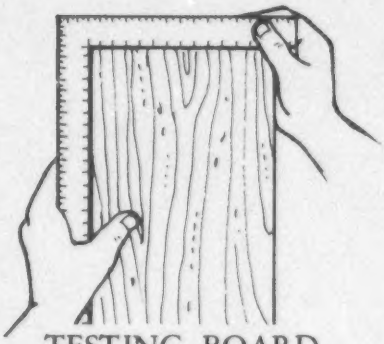
READING THE RULE



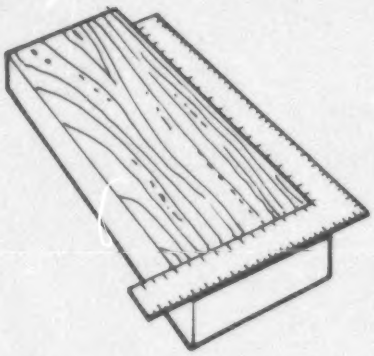
USE OF THE FRAMING SQUARE



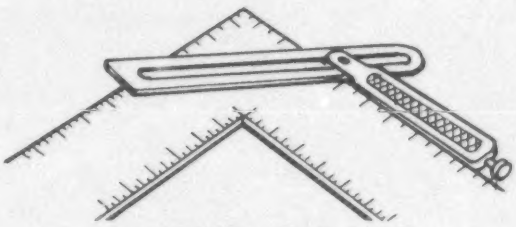
SQUARING BOARD



TESTING BOARD

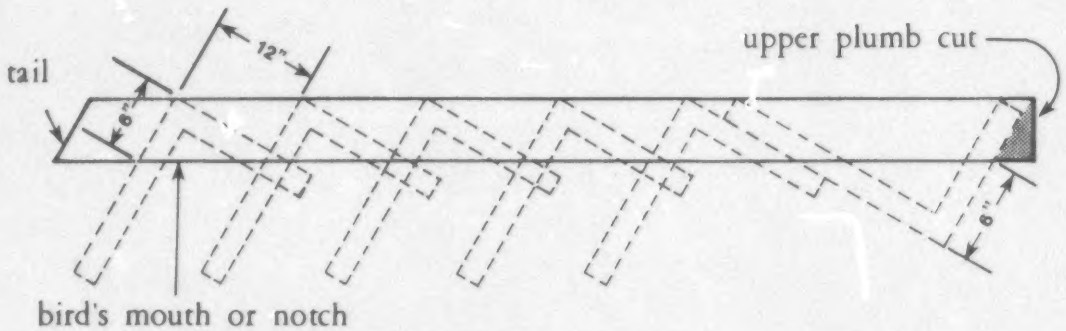


MEASURING BOARD

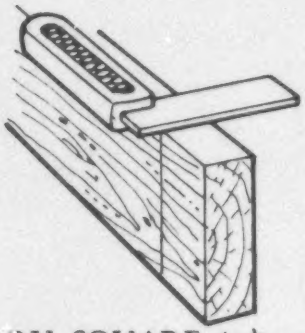


SETTING T-BEVEL

LAYING OUT COMMON RAFTER

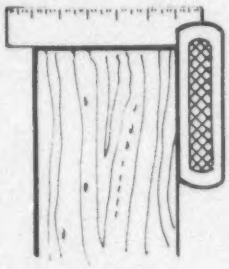


USE OF SQUARES

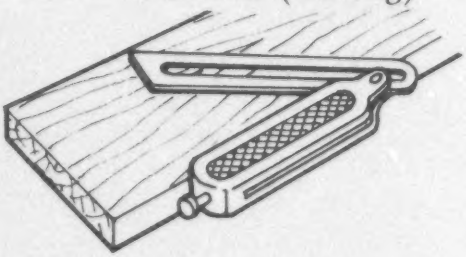


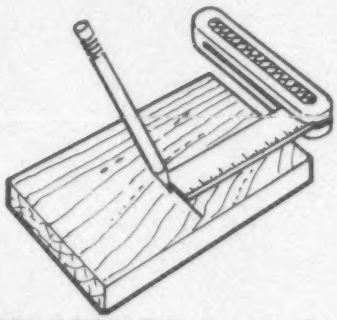
TRY SQUARE (edge squaring)

TRY SQUARING (testing cut)

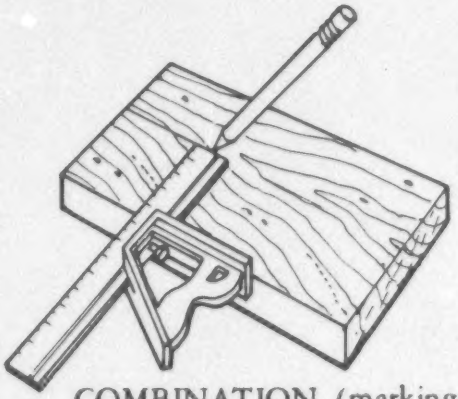


T-BEVEL (marking)

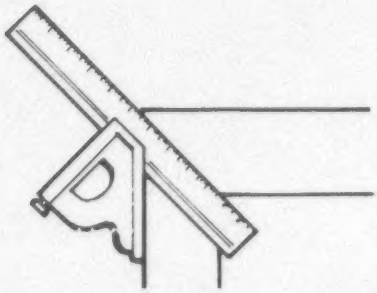




TRY SQUARE (measuring)



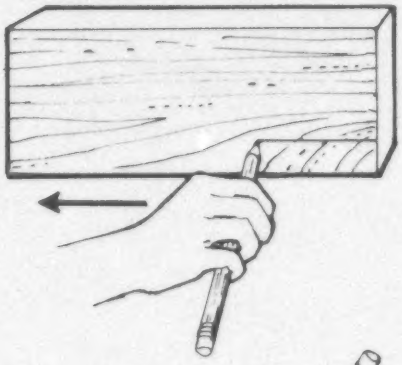
COMBINATION (marking board)

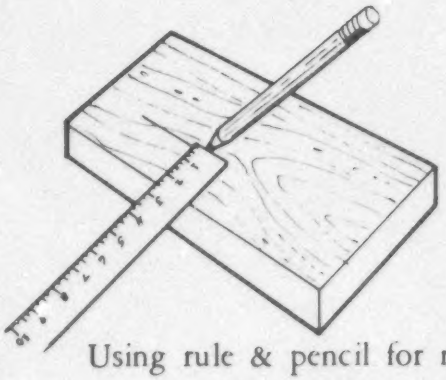


COMBINATION
(testing 45° angle)

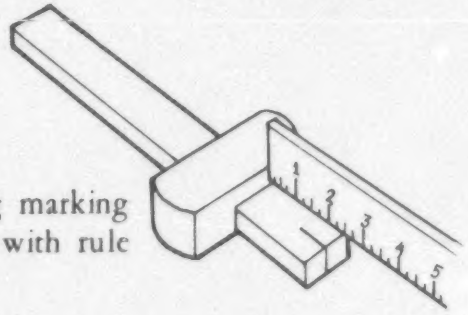
MARKING DEVICES

Using pencil only for marking

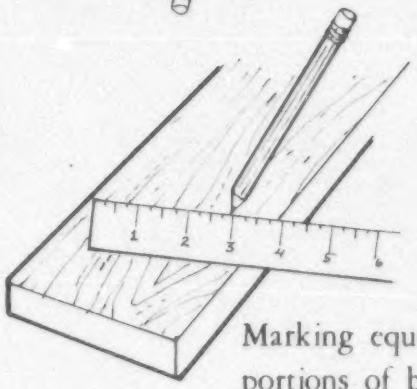




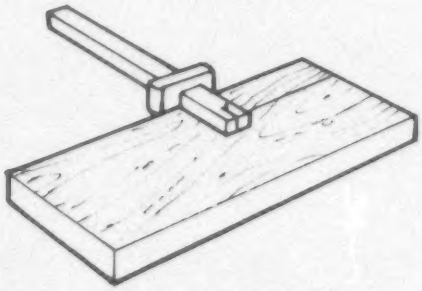
Using rule & pencil for marking



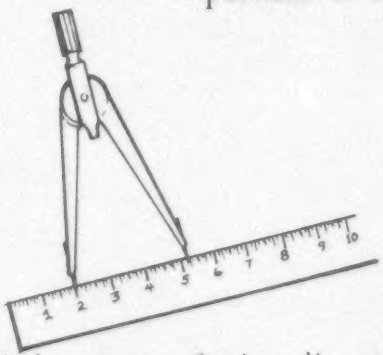
Setting marking gauge with rule



Marking equal portions of board

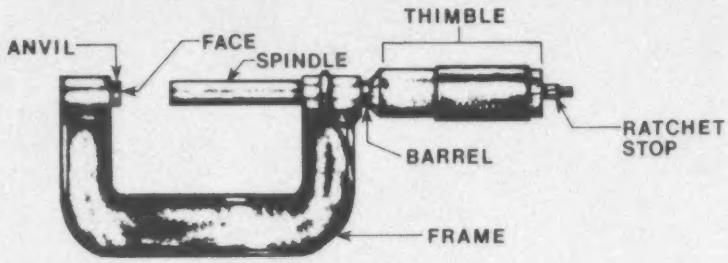


Using marking gauge

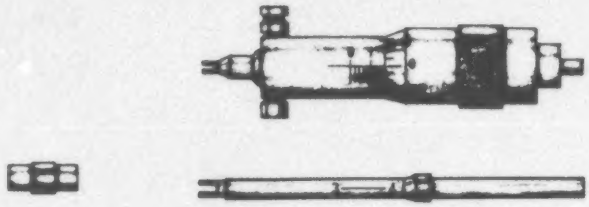


Marking circles or transferring distance

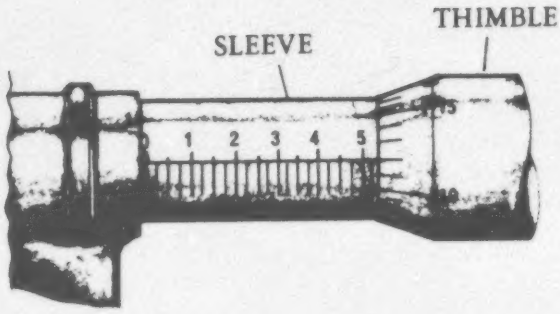
PRECISION MEASURING TOOLS



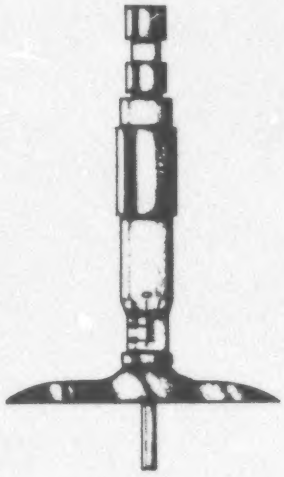
OUTSIDE MICROMETER



INSIDE MICROMETER

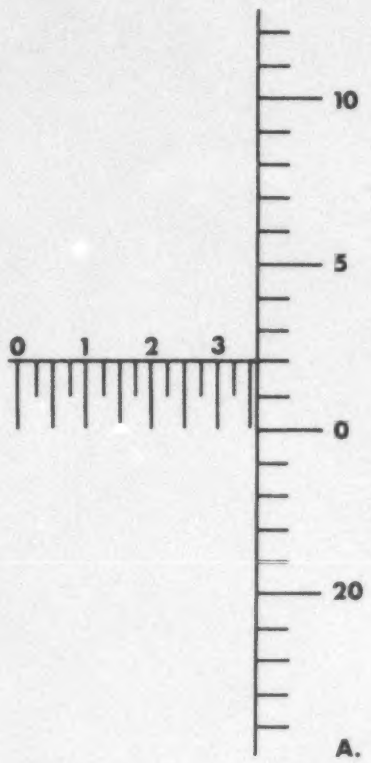


MICROMETER READING .537

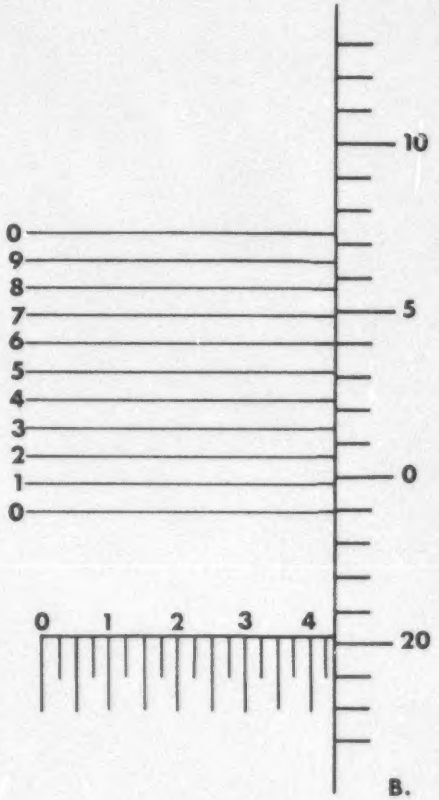


DEPTH MICROMETER

READING A MICROMETER



A.

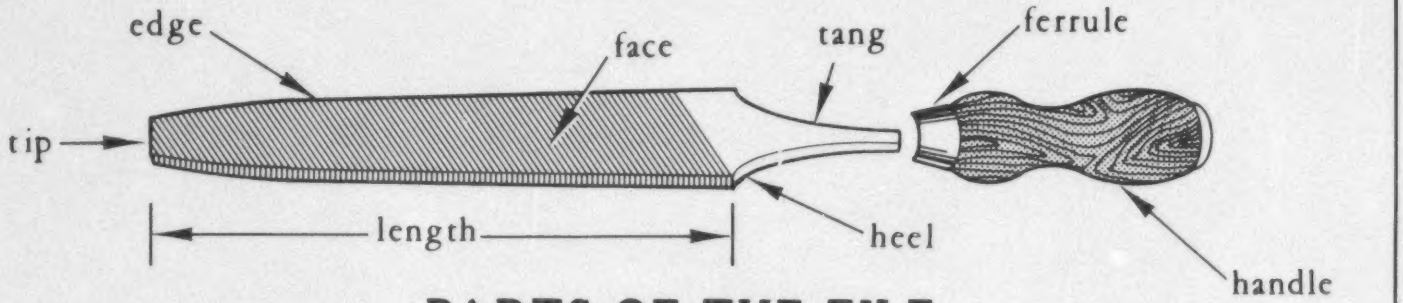


B.

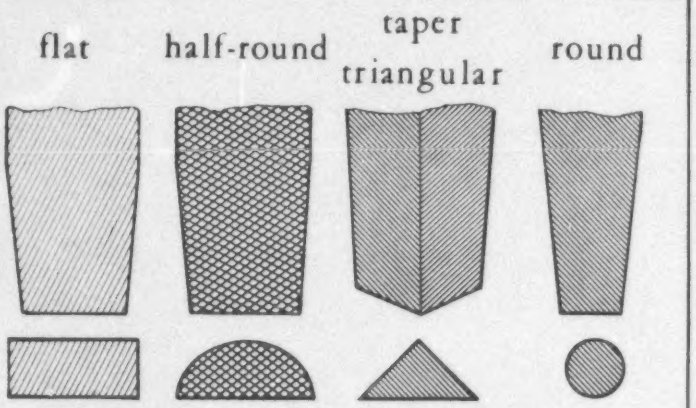
A.	Sleeve	3 = .300
	Sleeve	2 = .050
	Thimble	2 = .002
	TOTAL	.352

B.	Sleeve	4 = .400
	Sleeve	1 = .025
	Thimble	20 = .020
	Barrel—Vernier	= .0006 (6/10,000")
	TOTAL	.4456

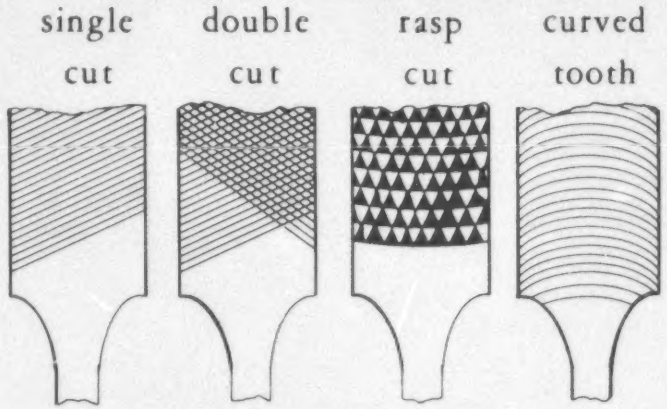
TYPES OF FILES



PARTS OF THE FILE

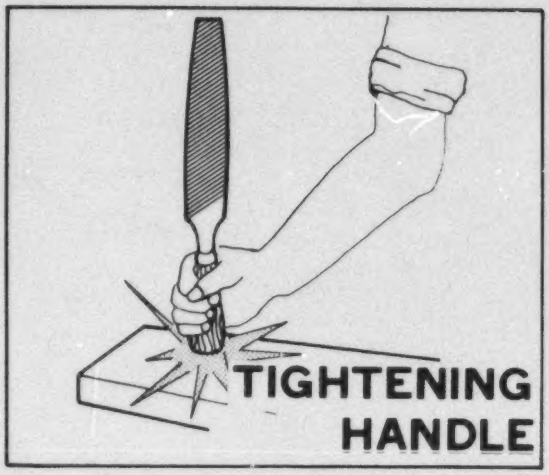


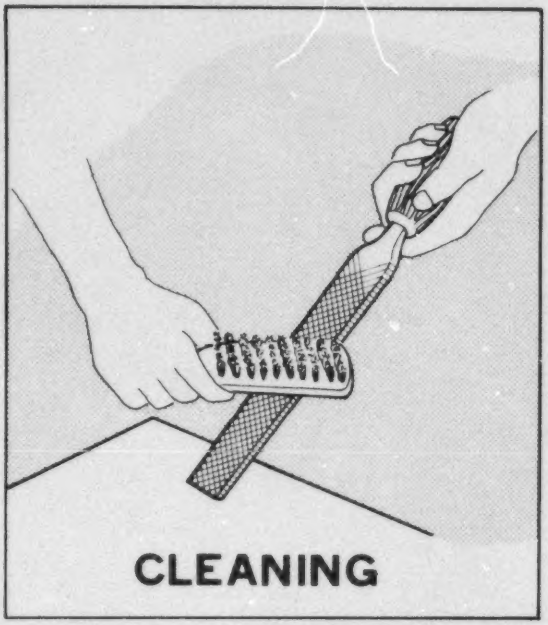
TYPES OF FILES

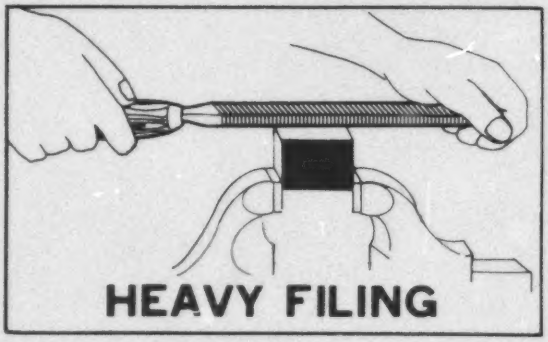


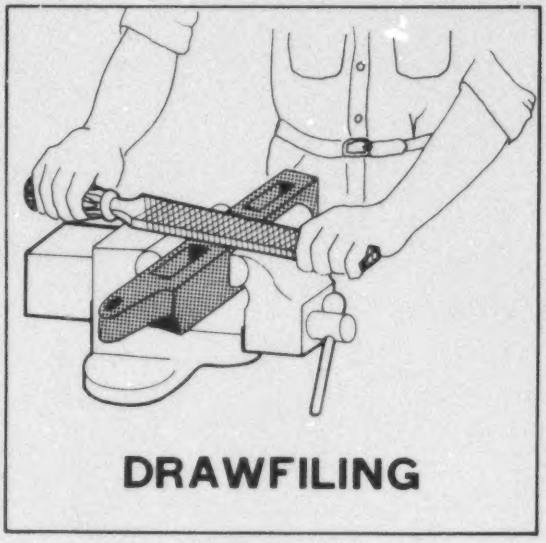
TYPES OF TEETH

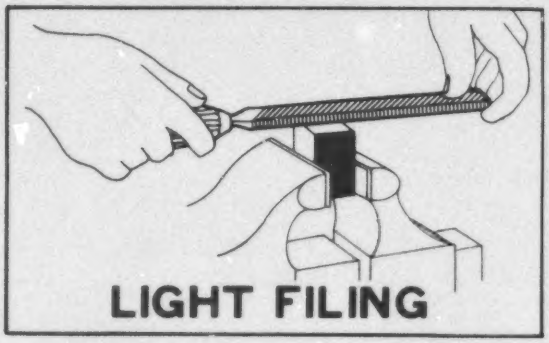
USING THE FILE



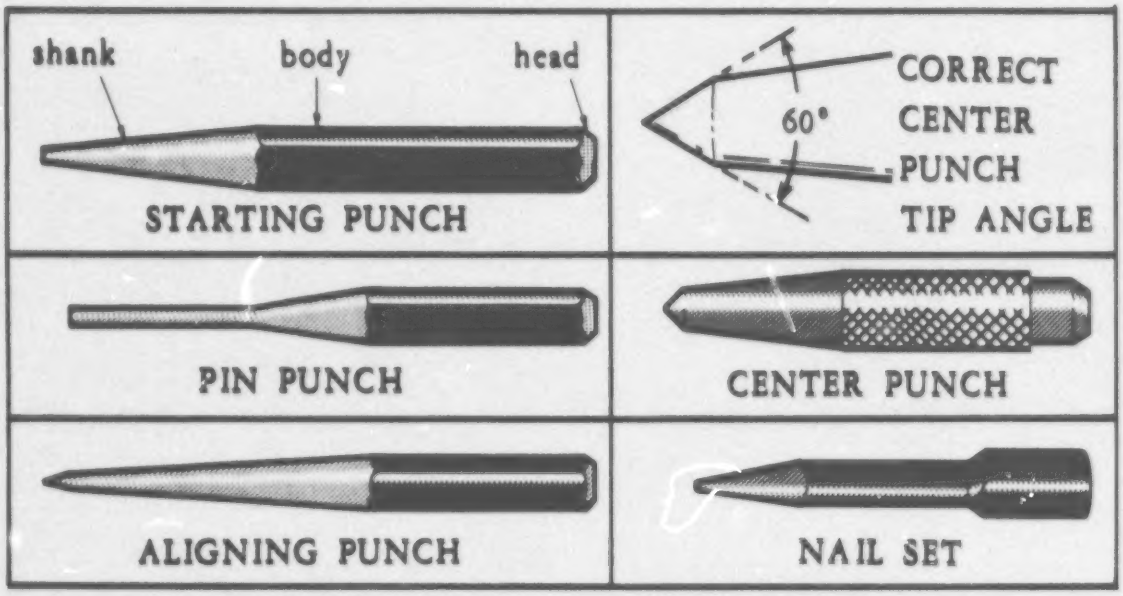




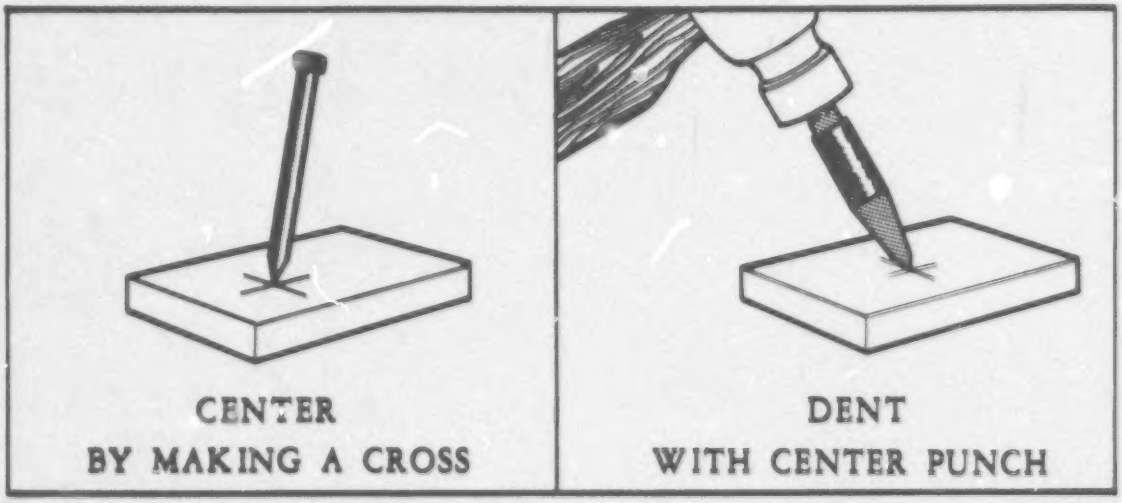




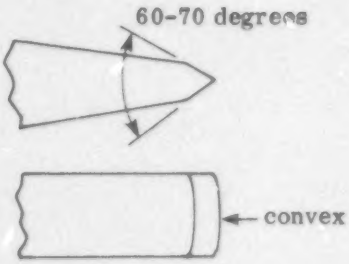
TYPES OF PUNCHES



USING THE CENTER PUNCH



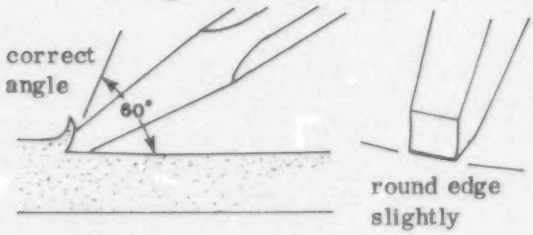
TYPES OF COLD CHISELS

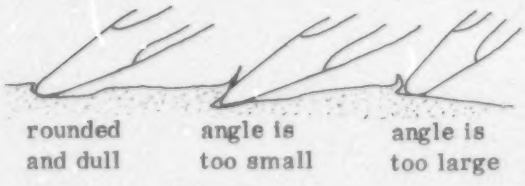


correct shape of flat cold chisel edge

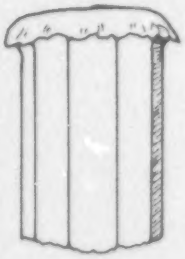
flat chisel

using the flat chisel



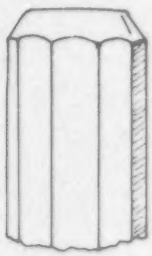


mushroomed head



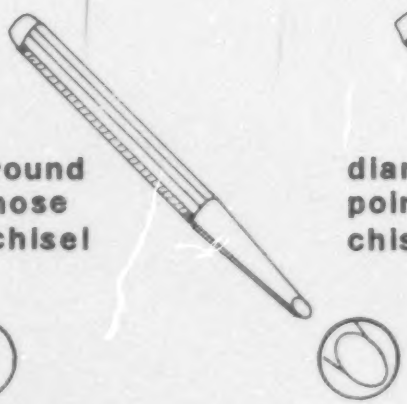
wrong

correctly ground



right

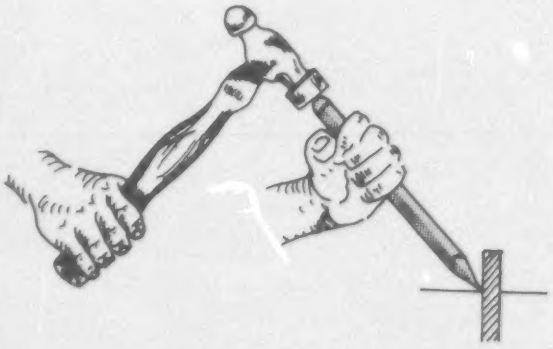
cape chisel

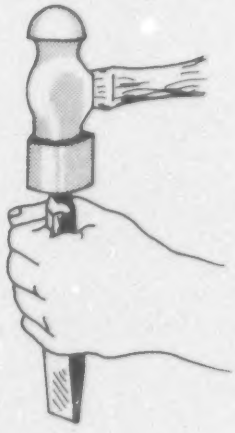


round nose chisel

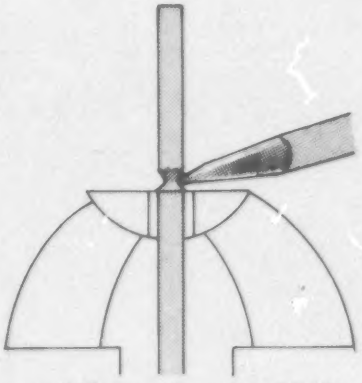
diamond point chisel

USING THE COLD CHISEL

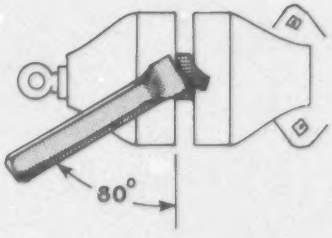




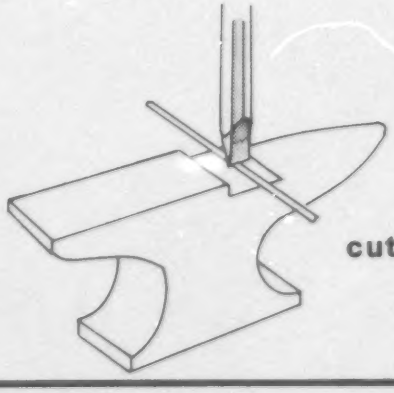
use of Ball Peen hammer with chisel



cutting round stock

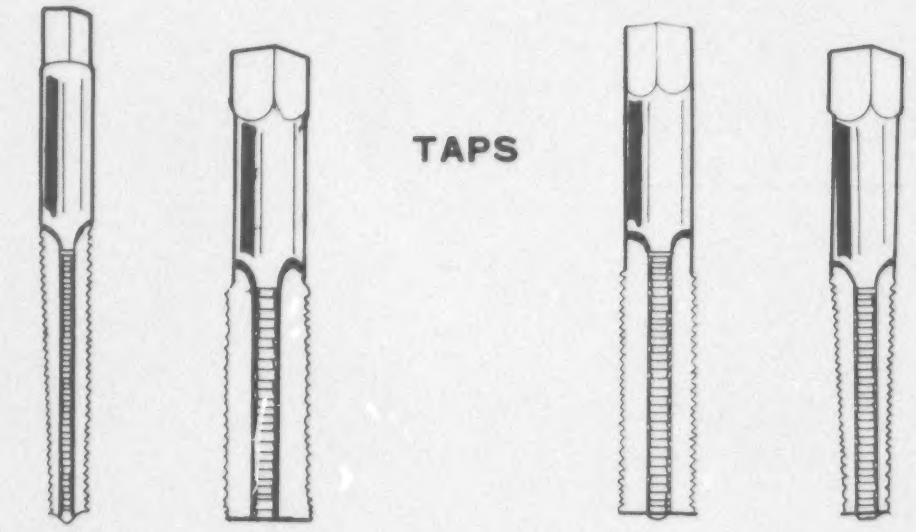


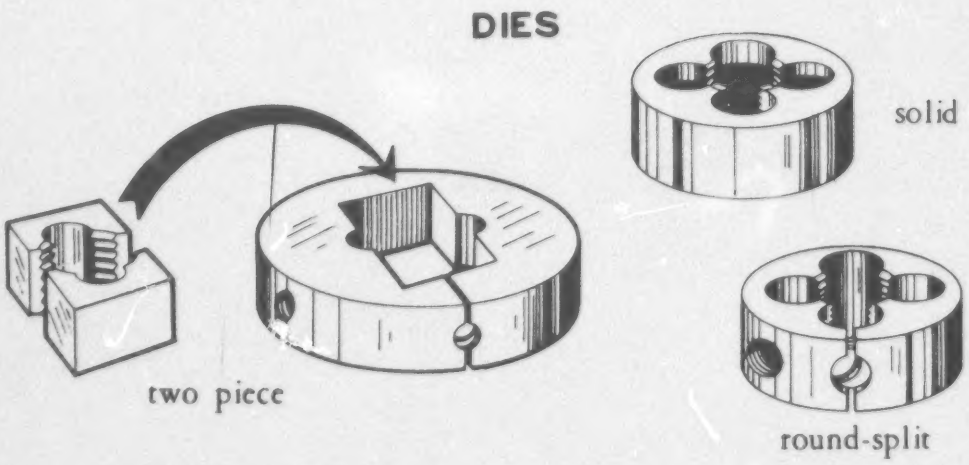
cold chisel cutting angle



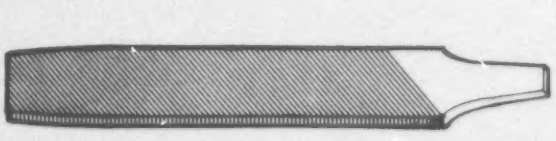
cut metal on anvil ledge

TAPPING & THREADING





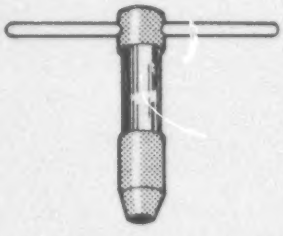
TOOLS FOR THREADING AND TAPPING



FLAT FILE

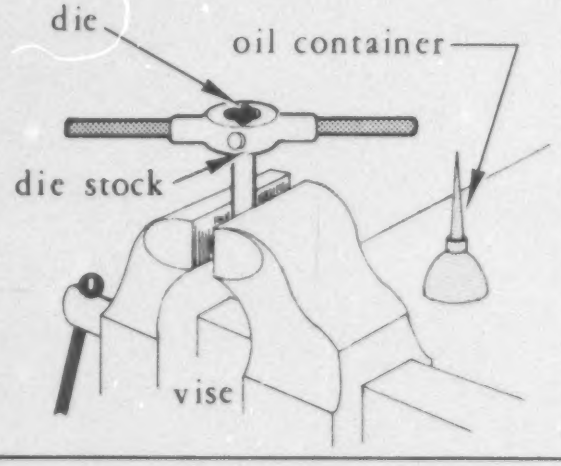
DIE STOCK

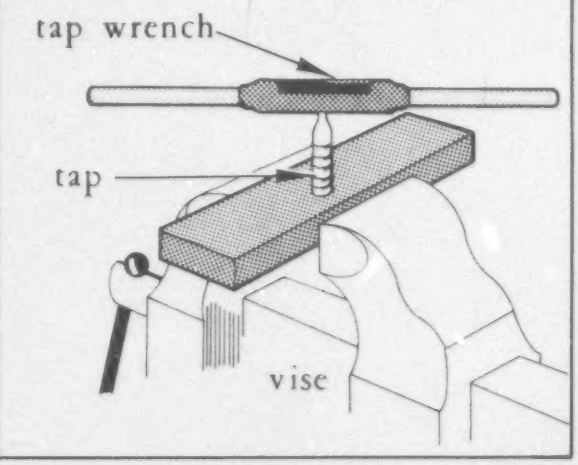
TAP WRENCH



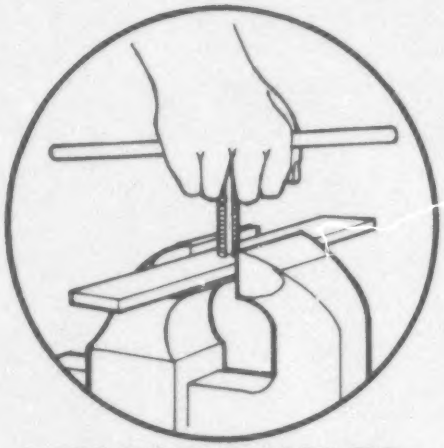
T-TAP WRENCH

PUNCH

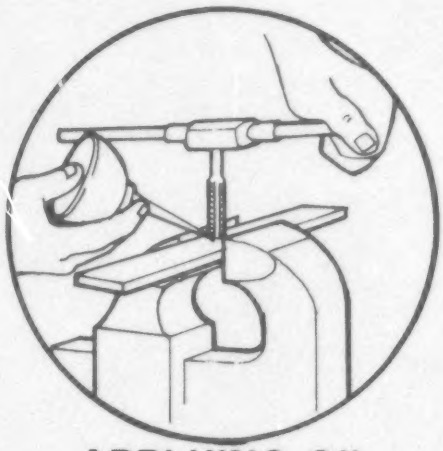




TAP AND DIE PROCEDURES

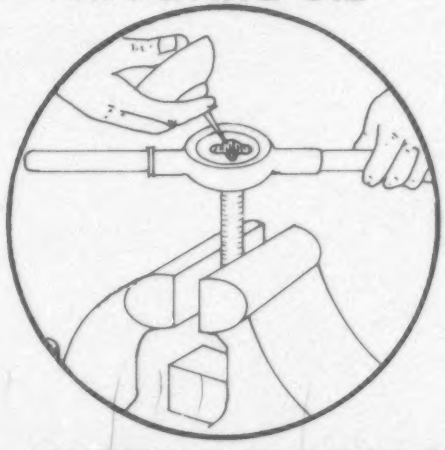


TAPPING HOLES

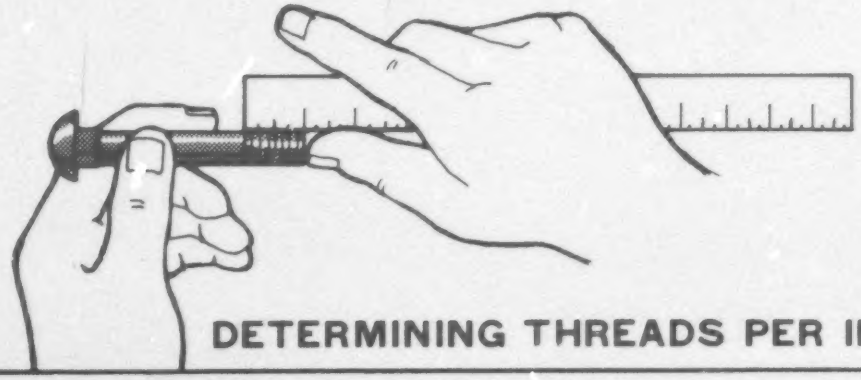


APPLYING OIL

THREADING A BOLT OR ROD

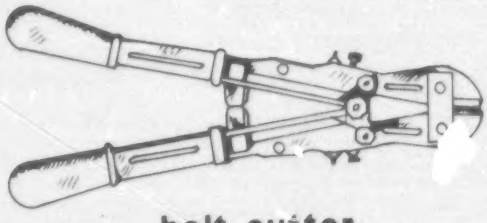


CUTTING THREADS

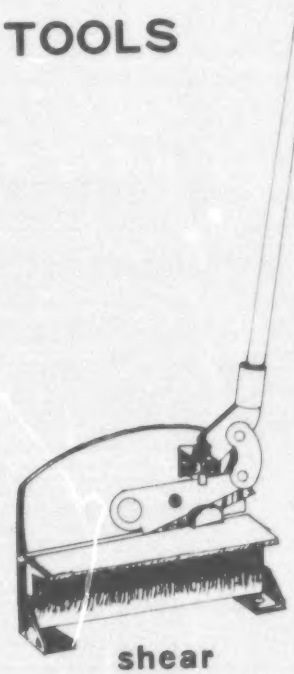


DETERMINING THREADS PER INCH

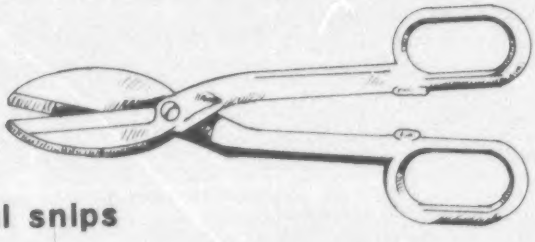
TYPES OF CUTTING TOOLS



bolt cutter

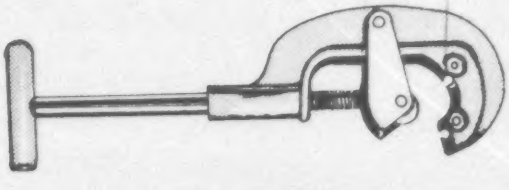


shear



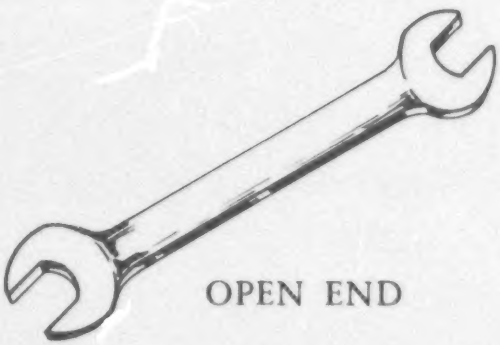
sheet metal snips

tubing cutter

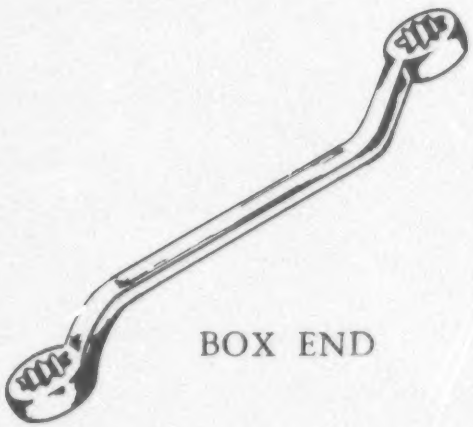


pipe cutter

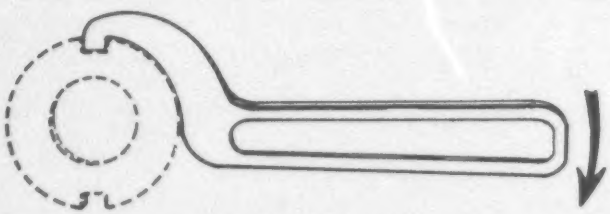
TYPES OF WRENCHES
FIXED JAW



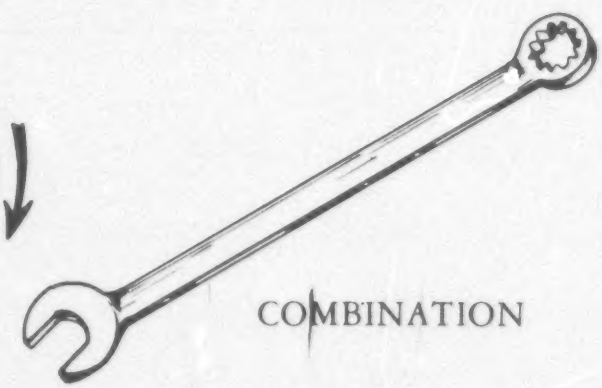
OPEN END



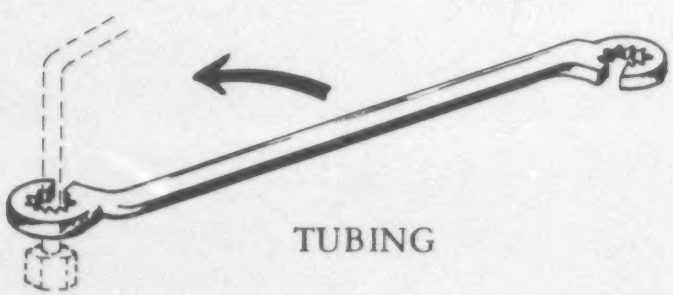
BOX END



HOOK SPANNER

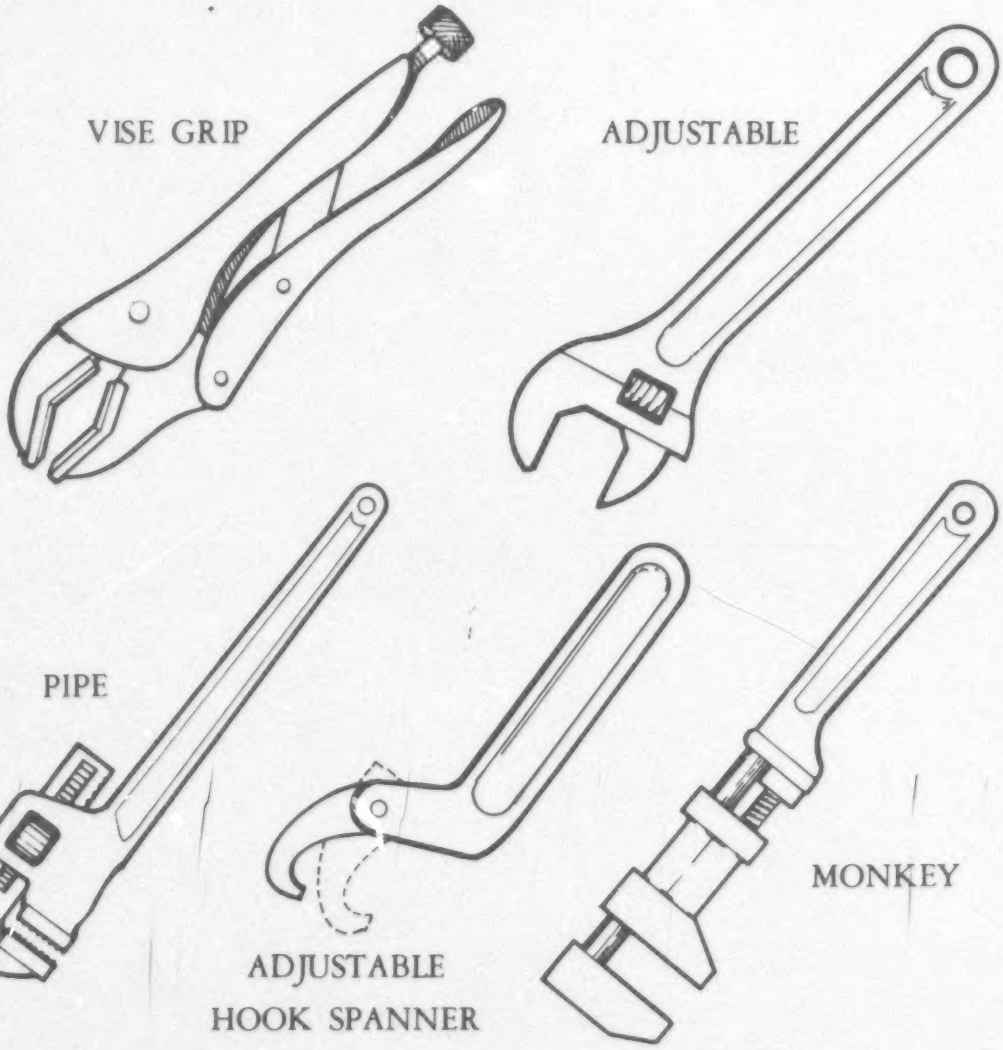


COMBINATION



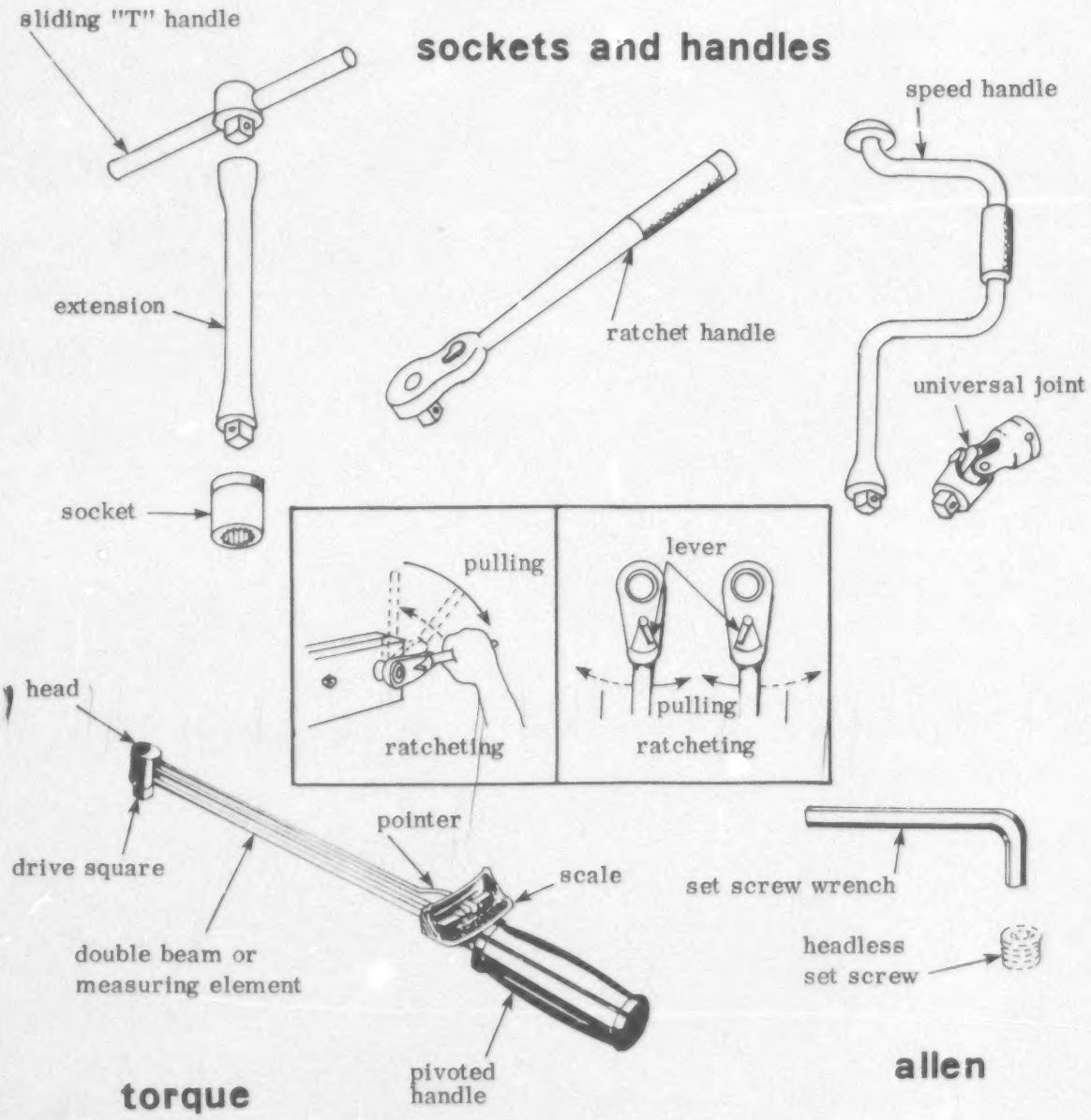
TUBING

TYPES OF WRENCHES

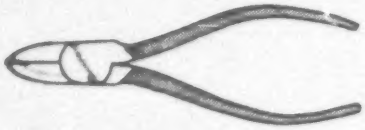


ADJUSTABLE JAW

TYPES OF WRENCHES



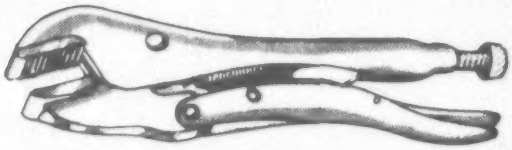
TYPES OF PLIERS



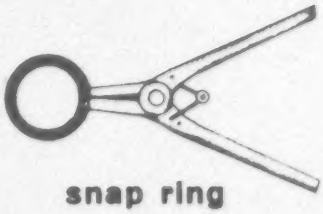
diagonal cutter

side cutter

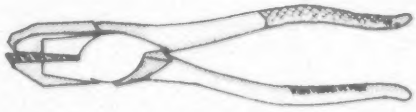
needle-nose



lock-grip



snap ring



linemen's

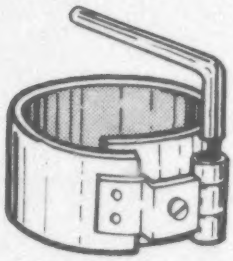
adjustable channel lock

fence

the slip joint permits jaws to be opened wider

combination

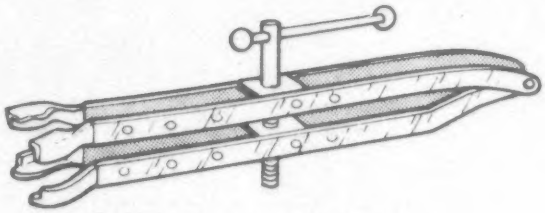
SMALL ENGINE REPAIR TOOLS



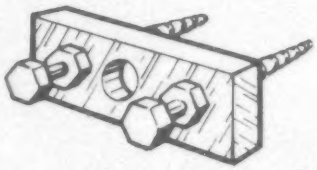
RING COMPRESSOR

FLYWHEEL HOLDER

STARTER WRENCH

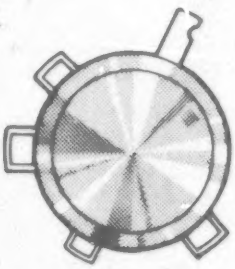


SPRING COMPRESSOR



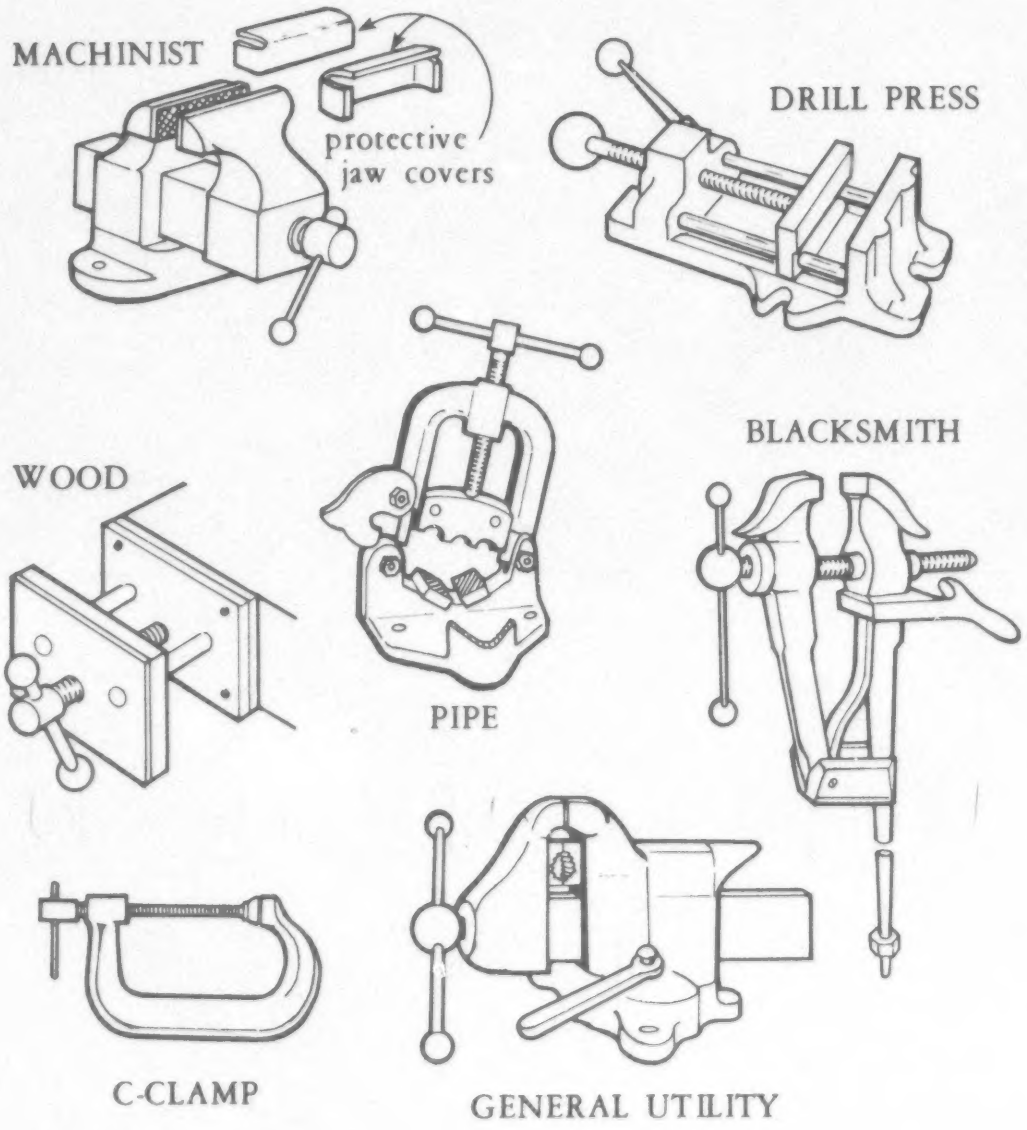
FLYWHEEL PULLER

SPARK TESTER

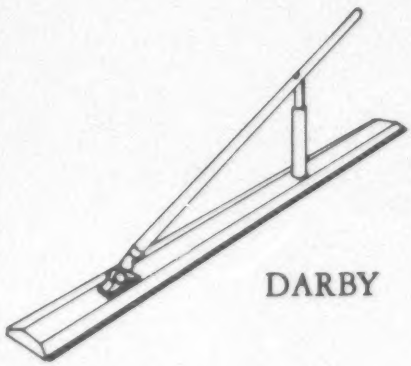


PLUG GAP GAUGE

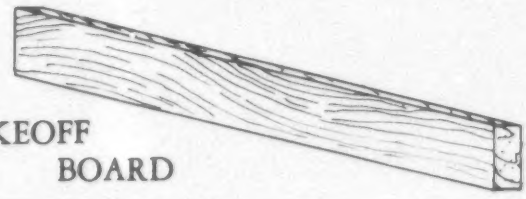
TYPES OF VISES

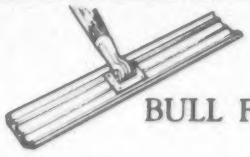


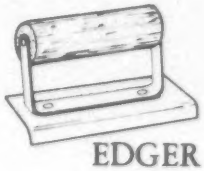
FINISHING EQUIPMENT AND TOOLS

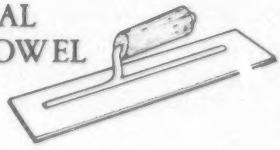

DARBY

VIBRATOR


STRIKEOFF BOARD


BULL FLOAT

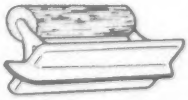

EDGER

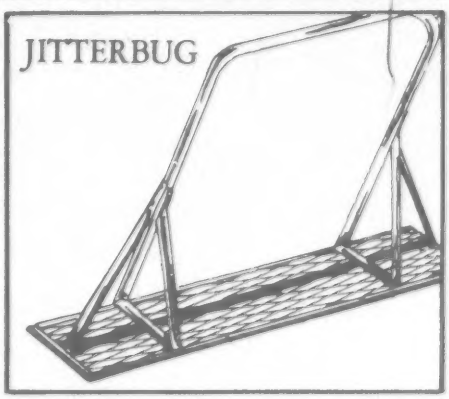

METAL TROWEL

METAL FLOAT

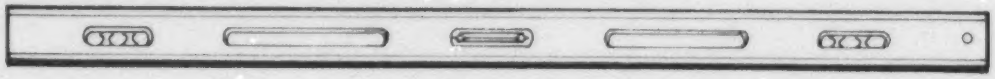
WOOD FLOAT

POWER TROWEL

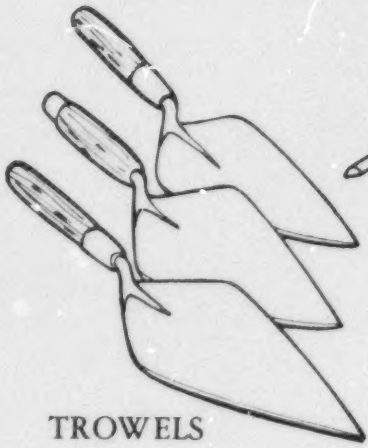

JOINTER OR GROOVER


JITTERBUG

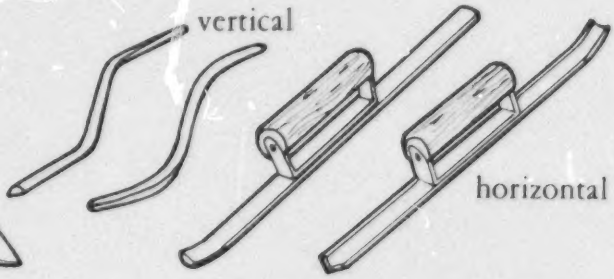
MASONRY TOOLS



LEVEL OR PLUMB RULE

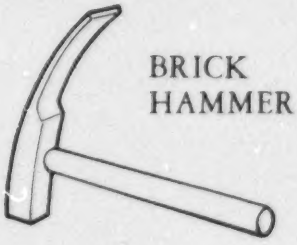


TROWELS

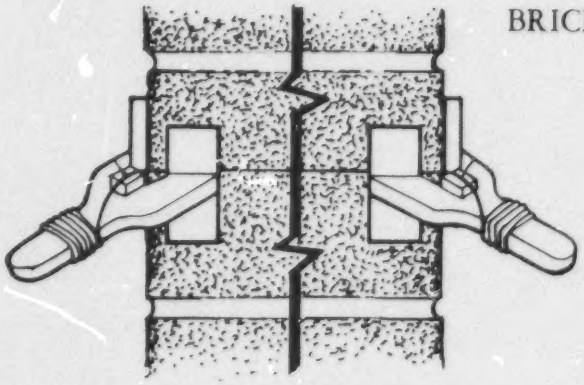


JOINTERS

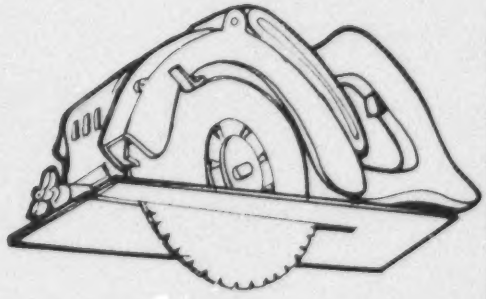
BRICK SET



BRICK HAMMER



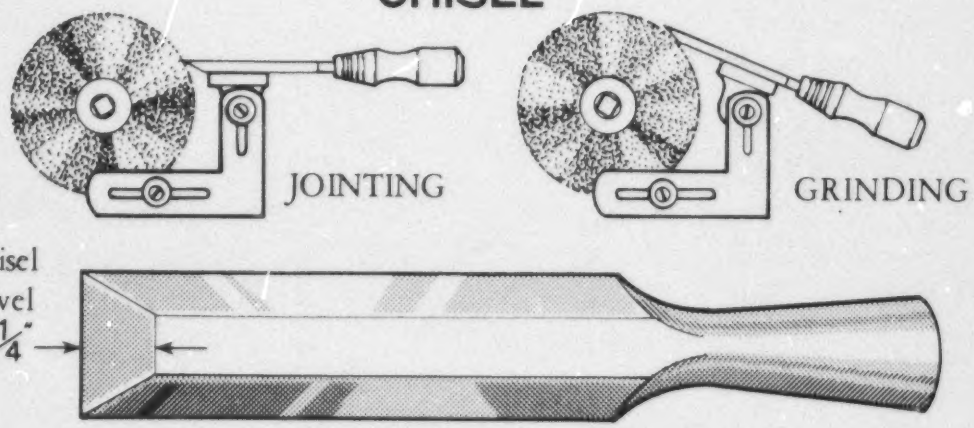
CORNER BLOCKS



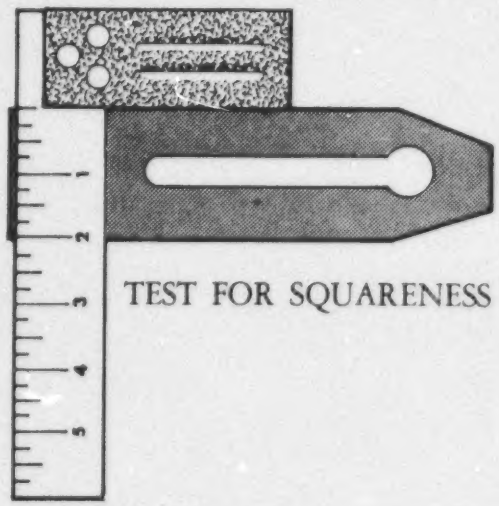
ELECTRIC PORTABLE SAW

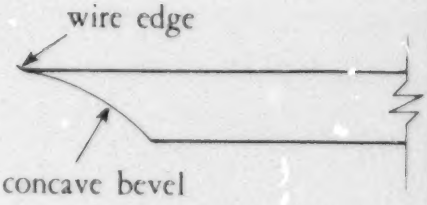
GRINDING WOOD CHISELS & PLANE IRONS

CHISEL

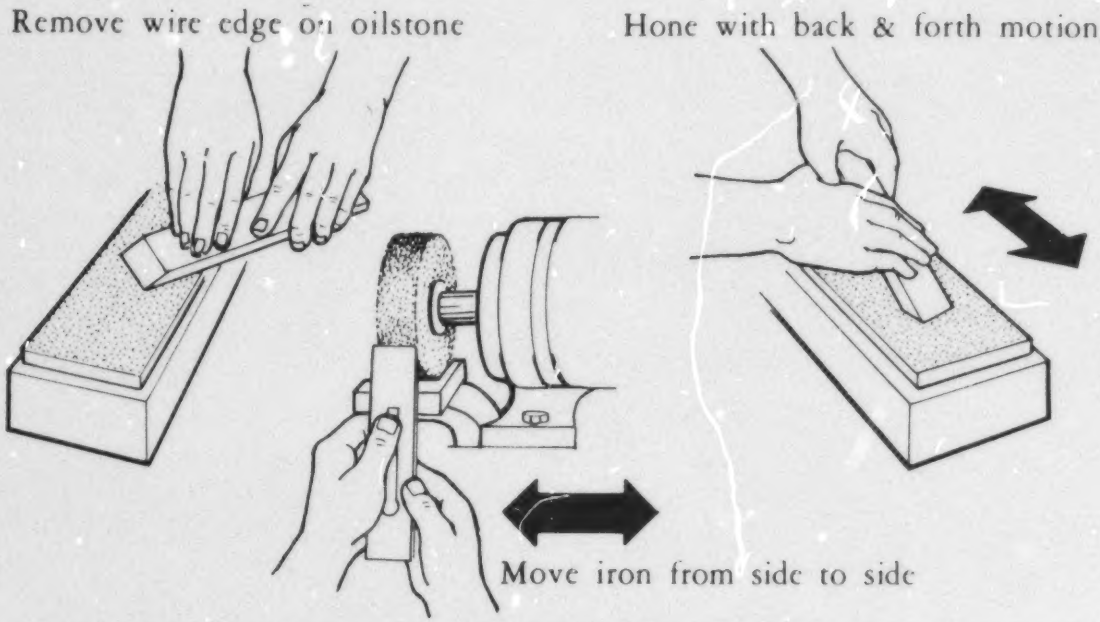


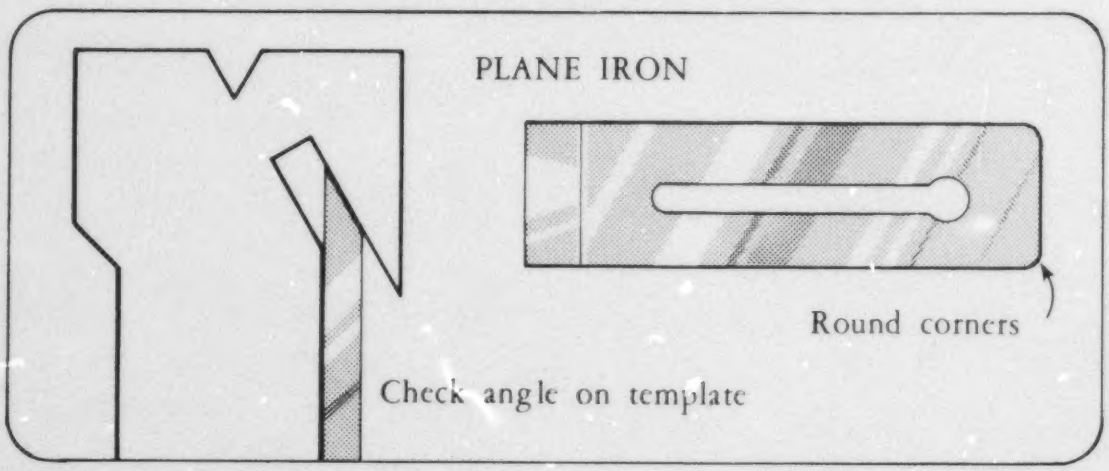
PLANE IRON



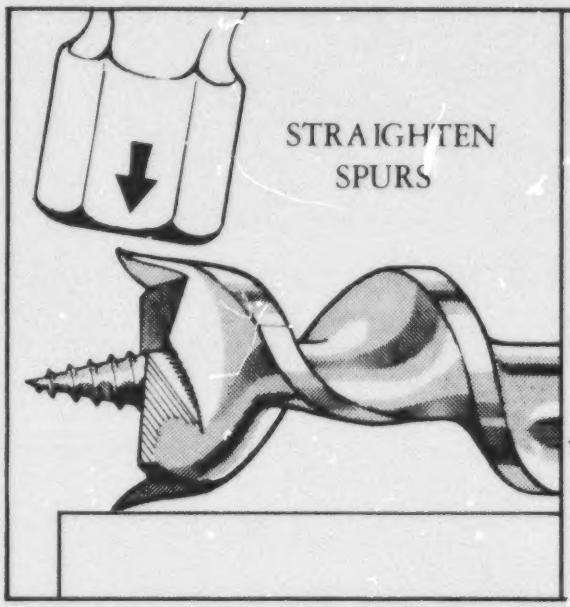


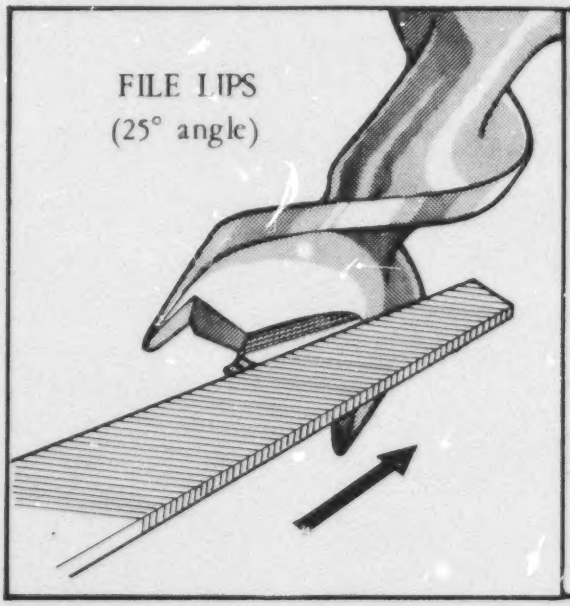
GRINDING & HONING PLANE IRONS & WOOD CHISELS



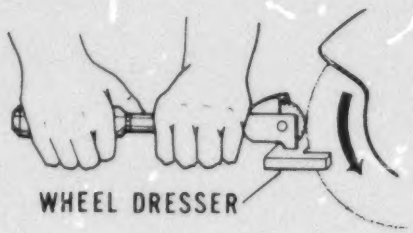


RECONDITIONING AUGER BIT

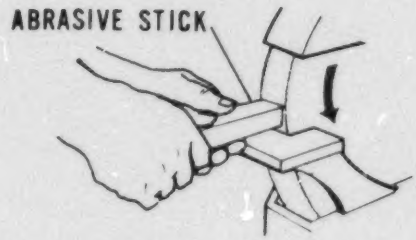




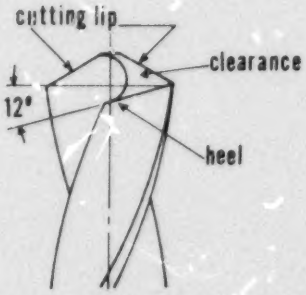
RECONDITIONING TWIST DRILLS



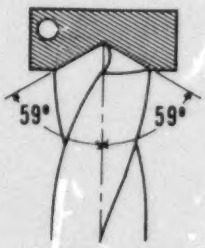
DRESSING STONE



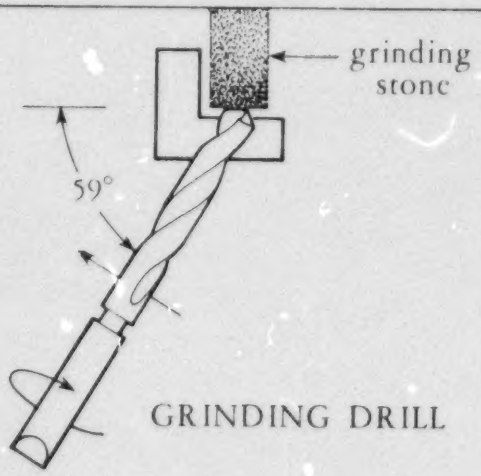
DRESSING STONE



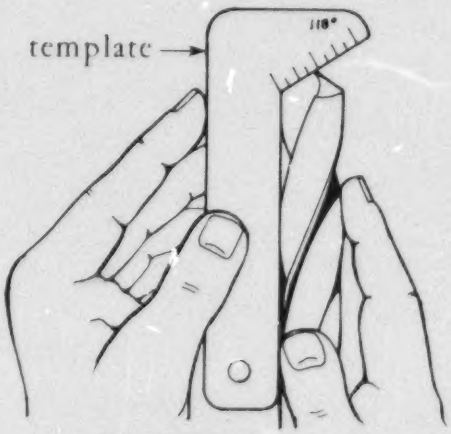
PARTS OF TWIST DRILL



TWIST DRILL ANGLE

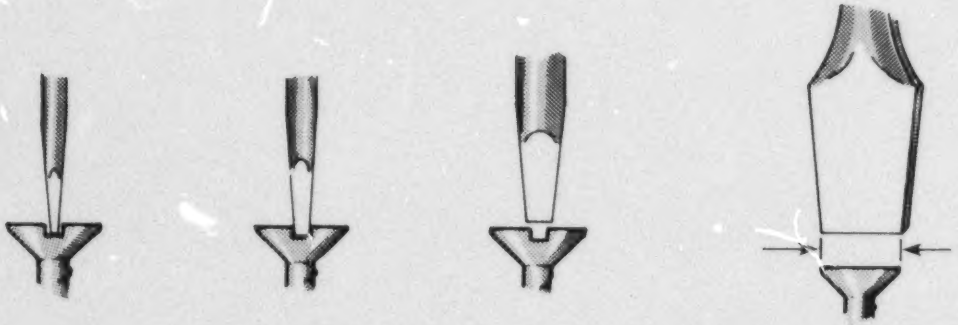


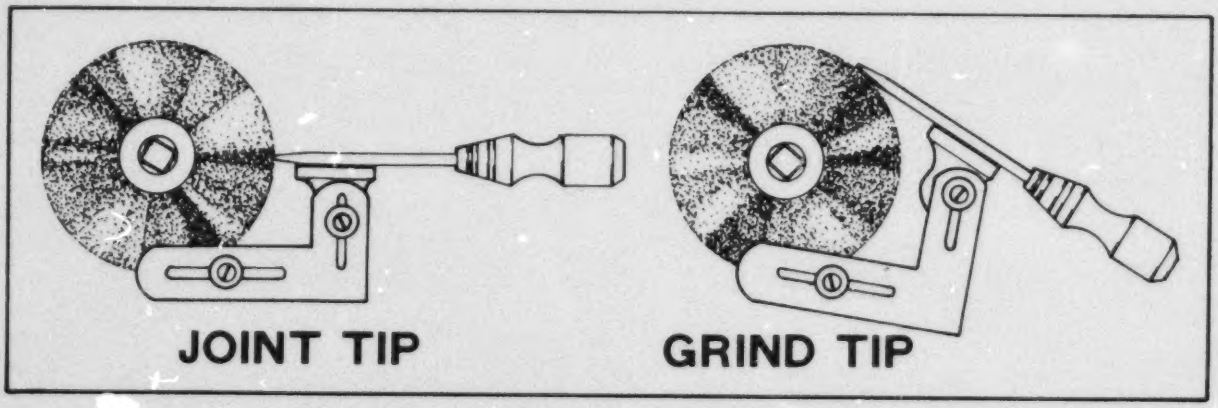
GRINDING DRILL



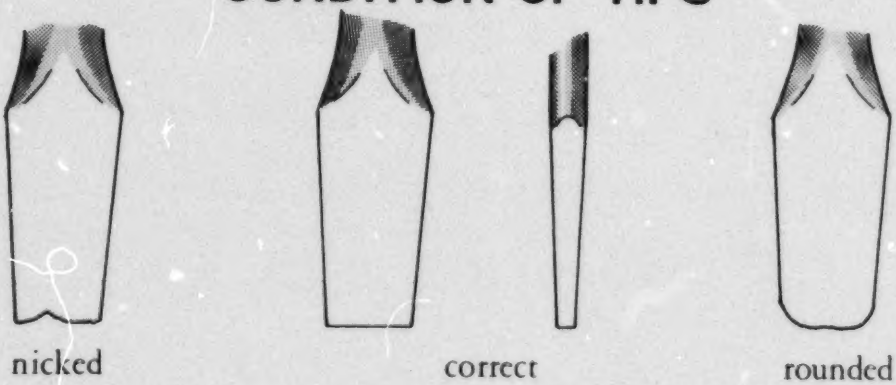
CHECKING ANGLE

REFITTING SCREWDRIVERS

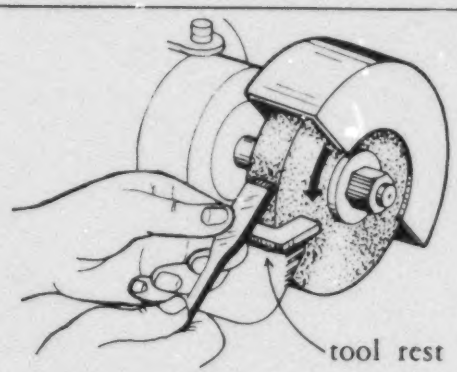




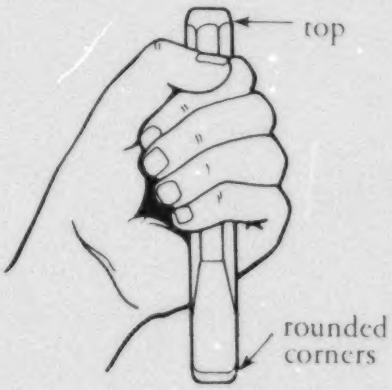
CONDITION OF TIPS



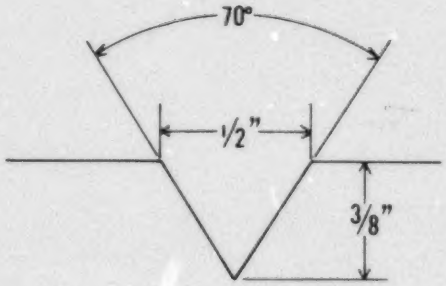
SHARPENING CHISELS AND PUNCHES



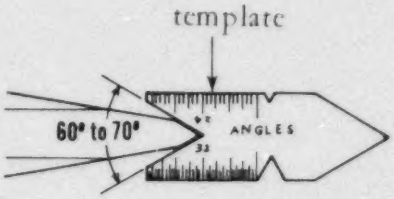
GRINDING CHISEL



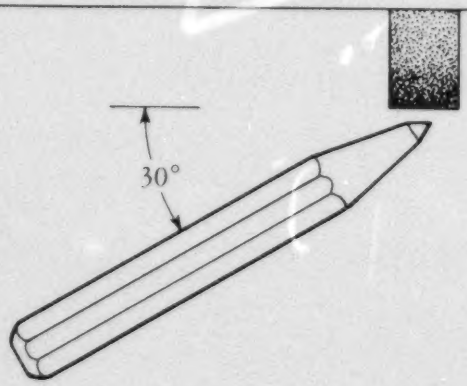
CONDITIONED CHISEL



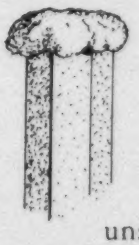
TEMPLATE-ANGLE GAUGE



CORRECT CHISEL ANGLE



GRINDING CENTER PUNCH



MUSHROOMED HEAD

CONSTRUCTION AND MAINTENANCE

Unit A: Introduction

Topic 4: Identification and Use of Power Tools

Suggested Procedures and Activities: Following a discussion and demonstration of each power tool, students may be permitted to identify each tool and its parts, then make adjustments and perform assigned skills.

1. Safe Use of Power Tools

The following safety precautions should be observed while operating all power tools:

a. Safety glasses, goggles, or face shields should be worn by the tool operator and all observers.

b. Shop workers should dress properly for the job.

c. Horse-play and other distractions should be avoided while working in the shop.

d. Tool cutting edges should be sharp, protected by guards, and off-limits to fingers.

e. Tools and equipment should be safety grounded.

f. Tool and equipment adjustment should be done with the power disconnected.

g. Shop workers should be alert and direct attention only to the job being performed.

h. When appropriate, use push stocks and roller support stands.

i. Stock being cut should be free from foreign material.

j. Shop work areas should be properly ventilated.

k. Electrical extension cords and power leads should be of adequate gauge and the insulation should be regularly checked for cracking and cuts that could expose bare wire.

l. Power tools and equipment should receive regular lubrication and maintenance.

m. Good housekeeping should be practiced in the shop.

n. Non-slip adhesive should be placed on the floor in front of machines to prevent the operator from slipping.

o. Shop workers should be closely supervised at all times.

Transparencies Nos. 1 and 2

2. Types of Saw Blades

a. Circular saw blades

(1) Crosscut - The crosscut blade is used to make smooth cuts across the grain.

(2) Rip - The ripping blade is used to make smooth fast cuts with the grain.

(3) Combination - The combination blade is used to make fast cuts with or across the grain.

(4) Carbide-tipped - The carbide-tipped blades are more expensive, but have a longer life.

(5) Dado head - The dado head is used for making selected dado cuts.

b. Other saw blades

(1) Hacksaw - The hacksaw blade is selected by length, gauge, set of teeth, teeth per inch, and metal hardness.

(2) Band saw - The band saw blade is similar to the hacksaw blade, except it is a continuous band.

Note: Both hacksaw and bandsaw blades should be selected to allow three teeth to be in contact with the edge or surface of the stock being cut.

(3) Sabre saw - Sabre saw blades are of three types: knife, for cutting leather, plastics, etc.; metal cutting; and, wood cutting. Wood cutting blades have 6 to 12 teeth per inch and metal cutting blades have 16 to 32.

Transparency No. 3

3. Portable Circular Saw

a. Parts of the portable circular saw

(1) Handle
(2) Power cord
(3) Guide knob
(4) Angle scale
(5) Tilt lock knob
(6) Rip guide lock knob
(7) Tilting base
(8) Anti-kickback clutch
(9) Trigger switch
(10) Guard lift handle
(11) Retractable guard
(12) Blade

Transparencies Nos. 4 and 5

b. Uses of the portable circular saw

The circular electric handsaw actually replaces the handsaw and in most instances takes the place of the bench or circular table saw. This saw is most useful for gang cutting of studding, trimming roof sheathing, cutting paneling, and cutting of large quantities of material at any one time in the same or different locations on any particular job. The saw can be used for ripping, crosscutting, dadoing, grooving, cutting angles or bevels, and mitering. By using special blades the saw will cut metal, stone, glass, and tile. The portable electric power saw is really considered to be one of the most important labor saving pieces of equipment in any shop program. It can be carried to the job instead of the job being carried to it as in the case of a table saw. It saves time and energy as compared to use of the handsaw.

c. Procedure for using the portable circular saw

(1) Select a sharp blade of the correct type.

(2) Properly adjust the saw and be sure all thumbscrews are tight.

(3) The blade should be installed so that the teeth turn up toward the saw base.

(4) The teeth should extend below the thickness of the material to be cut to a distance equal to the depth of the teeth.

(5) Secure the material to be cut.

(6) The operator should stand in a safe position, start the saw before the blade makes contact with the stock, and saw only in a forward direction. The saw must be guided along a straight line.

(7) Both hands can be used to hold and guide the saw.

(8) If the blade binds while ripping, a wedge may be placed in the saw kerf to give clearance.

(9) When the end of the cut is reached, release the trigger switch and allow the blade to follow through as the saw is lifted away from the work.

Note: In selecting portable circular saws, the motor rating, blade diameter, and arbor hole size should be considered.

Transparency No. 6

4. Sabre Saw

a. Parts of the sabre saw

(1) Power cord strain reliever
(2) Handle
(3) Brushes
(4) Base tilt adjustment
(5) Tilting base
(6) On-off switch
(7) Guide knob
(8) Housing
(9) Blade screw
(10) Toe
(11) Blade

b. Uses of the sabre saw

Sabre saws are referred to as electric jigsaws or bayonet saws. They operate by making a reciprocating motion or an orbital or oval motion. This type of motion allows the blade to make the cut on the upward stroke and releases the chips on the downward stroke. The stroke of the blade is about 1 inch. The reciprocating saw cuts on both upward and downward stroke. There is more blade drag and heating in this type of saw. The blade also cuts slower and dulls faster than the orbital type saw. The saw cut may vary from about 3200 to 4200 strokes per minute. The motor sizes vary from about 1/6 to 1/2 hp.

The sabre saw is considered to be very versatile, in that it can be used to cut wood, sheet metal, plastics, fiberglass, rods, tubing, rubber, masonite, leather, and other materials. It is found in the carpenter and cabinet shops and in carpenters', plumbers', and electricians' tool chests. In order to use the saw for cutting different types of materials, the proper type or kind of blade must be used.

c. Procedure for using the sabre saw

(1) Mark the material and either clamp it to a work table, put in a vise, or lay on saw horses to make the cut. Curved or scroll cut material may be moved as the cut is being made.

(2) Place the front edge of the saw shoe on the material, turn on the switch, and slowly push the blade into the material to be cut. Leave a little of the line or mark on the usable portion of the material.

(3) For most cutting jobs, use both hands on the handles to move the saw forward in a steady pace without forcing it. Some saws have a switch lock on the handle to keep the motor in operation for long cuts.

(4) When making a plunge cut, tilt the front of the base forward to clear the blade from the material. With the motor running at full speed, lower the back so that the blade will enter smoothly into the material at a place where it is marked. When the entire base is fully seated, move the saw forward to make the cuts along the inside of the marked area. If corners are to be cut, make the first cut to the corner edge, back the

blade in the cut, and cut a curve around to the side; cut this and the other corners in the same manner. Remove and reinsert the blade to cut the curved portions out of each corner. The plunge cut is used when no hole is bored to start the blade or when the blade is not started on the outside edge.

(5) Sawing metal is similar to sawing wood; the metal is marked and placed in a vise or clamped in position to a table top. The following steps should be observed when metal is being cut:

(a) Cut tubing, screen frame stock, and angle framing with a fine tooth blade instead of the 14-tooth blade.

(b) Cut tubing that is larger in diameter than the length of the blade by making a cut through the tubing to insert the sabre saw blade. Proceed to cut around the tubing, keeping the saw on top as the tubing is rotated.

(c) Cut very thin sheet metal by sandwiching it between scrap pieces of material (thin plywood). The outside edges should be clamped to prevent vibration. The line of cut should be laid out on the top part of the scrap material. This method of cutting thin sheet metal aids in preventing tearing.

(d) When cutting heavy metal (rods, bar stock, angle iron, or thick sheets) lubricate the blade before starting the cut with stick wax, and wax the blade while cutting if necessary.

(e) Change the saw blade if it bounces during its use. Do not start the new blade directly in the old cut. The new blade is thicker than the old blade; therefore, the teeth will be damaged. Start the new blade on the outside of the old cut and work it into the cut slowly.

(f) It is important that a sabre saw and the metal cutting blade do the work, so do not force the saw into the metal. A metal cutting job must not be rushed.

(6) Such materials as formica, plywood, and resin board are easily cut with the sabre saw. When cutting plywood use a base insert if the saw is equipped to accept the insert with a 10-tooth short blade. This 10-tooth blade is also recommended to cut synthetic resin board, formica, and masonite.

(7) The sabre saw can also be used to notch heavy lumber. Mark such materials as rafters, braces, and wall studs (2 X 4's) and place them on a saw horse for notching or making other forms of cuts. Notching for plumbing or electrical fittings can be accomplished with the sabre saw.

(8) There are two special attachments that can be used on certain types of sabre saws. For example, in order to make up to a 45-degree angle cut, remove the regular base and attach the angle adjustable base. When cutting material a certain length or width attach the saw guide to the regular base to make the cut.

Transparency No. 7

5. Reciprocating Saw

a. Parts of the reciprocating saw

(1)	Blade	(6)	Switch lock
(2)	Blade set screw	(7)	Handle
(3)	Motor housing	(8)	Power cord
(4)	Brushes	(9)	Air vents
(5)	Trigger switch	(10)	Rocker shoe

b. Uses of the reciprocating saw

The reciprocating saw is more versatile than the sabre saw because it is designed to make cuts in any direction. Blades are manufactured to cut wood, steel, plastics, and other materials. The blades vary in length from 2½ inches to 18 inches. There are normally 6-10 teeth per inch for wood and 18-24 teeth per inch for metal cutting. Most reciprocating saws are two-speed, high speed for wood and low speed for metal cutting. The rocker type shoe allows rolling the blade into starting cuts. The blade can be inserted vertically or in a horizontal position in relation to the rocker shoe.

c. Procedure for using the reciprocating saw

(1) Set the speed depending on material to be cut.

(2) Secure the stock to be cut.

(3) Turn the finish side of the stock down during the cutting operation.

(4) Hold the rocker shoe tightly against the stock.

(5) Allow the saw to do the work, do not force the cut.

Transparency No. 8

6. Router

a. Parts of the router

(1) Brushes
(2) Housing
(3) Depth adjustment
(4) Guide knob
(5) Locking handle
(6) Motor cooling fan
(7) Sub-base
(8) Handle
(9) Trigger switch
(10) Motor safety disconnect
(11) Cord strain reliever
(12) Collet type chuck

b. Uses of the router

The router is used to make molding, dado, and rabbet cuts. Caution should be taken while using the router as the cutter bit travels up to 30,000 rpm and the bit cannot have a guard or it would not function.

c. Procedure for using the router

(1) Insert a sharp cutter bit suitable for the job.

(2) Adjust and lock the depth of cut. Be sure the cutter bit is tight.

(3) Secure the stock.

(4) Use a well-balanced stance and hold the router with both hands to resist the starting torque and properly guide the cut.

(5) Do not start the router with the cutter bit in contact with the stock.

(6) In cutting a straight edge, move from left to right. Make end grain cuts first.

(7) Move counterclockwise when making circular cuts.

(8) Use a steady, slow, even movement.

(9) Turn off the motor at the end of the cut and allow the bit to stop before lifting the router from the work.

Transparency No. 9

7. Portable Belt Sander

a. Parts of the portable belt sander

(1) Dust bag
(2) Switch lock
(3) Handle
(4) Trigger switch
(5) Brush holder
(6) Front handle
(7) Housing
(8) Belt
(9) Belt striker bar
(10) Belt tracking adjustment

b. Uses of the portable belt sander

The portable belt sander is used to dimension and finish surfaces depending upon the coarseness of the belt used. The advantage of the portable belt sander is the versatility of use. The belt sander is sized according to the dimensions of the sand paper belt. A three inch width is most common.

c. Procedure for using the portable belt sander

(1) Select the correct belt for the sander and the work to be done.

(2) Align and properly tension the belt.

(3) Secure the stock.

(4) Hold the sander with both hands and start the motor above the work.

(5) Allow the rear of the belt to touch first, leveling the sander as it moves forward.

(6) Sand in one direction, with the grain.

(7) Raise the sander at the end of each stroke.

(8) Lap each successive stroke about half way across the preceding one.

(9) Do not pause in one spot.

(10) Use finer grit belts until the desired finish is achieved.

(11) Lift the sander from the work, turn the motor off and allow it to stop before placing the sander on the work bench.

(12) Empty the dust bag as needed and clean the machine with compressed air.

Transparency No. 10

8. Finishing Sander

a. Parts of the finishing sander

(1) Brush holder	(6) Paper clamp
(2) Switch lock	(7) Pad
(3) Insulated trigger switch	(8) Paper clamp
(4) Contoured handle	(9) Housing
(5) Cord strain reliever	(10) Front hand knob

b. Uses of the finishing sander

The finishing sander may have an orbital or straight-line stroke and is used to do fine sanding before the final hand sanding operation. The finishing sander can use 1/3 of a standard 9" x 11" sheet of sandpaper.

c. Procedure for using the finishing sander

(1) Select the correct sandpaper for the job.

(2) Properly position the sandpaper on the pad and adjust the paper clamps to apply sufficient tension.

(3) Secure the stock.

(4) Start the sander above the work, then sand with the wood grain. The weight of the sander will provide adequate pressure.

(5) Sand with one hand.

(6) Use finer grit paper until the desired finish is obtained.

(7) Lift the sander off the work with the motor running when sanding is completed.

(8) Turn the motor off, then properly clean and store the sander.

Transparency No. 11

9. Portable Drill

a. Parts of the portable drill

(1) Housing
(2) Pistol grip handle
(3) Cord strain reliever
(4) Geared key chuck
(5) Cooling vents
(6) Reversing switch
(7) Trigger switch
(8) Switch lock
(9) Chuck wrench

b. Uses of the portable drill

The portable drill is used for drilling holes in metal, wood, plastics, and other materials. The size of the portable drill is determined by the largest diameter drill shank that can be inserted into the chuck. Drills can be selected according to size, motor rating, whether or not reversible, speed (single or variable), and type.

c. Procedure for using the portable drill

(1) Select a properly sharpened twist drill for the job.

(2) Tighten the chuck securely on the twist drill.

(3) Use a center punch or awl to locate the center of the proposed hole.

(4) Secure the stock.

(5) Hold the drill at the correct angle while applying a steady, even pressure.

(6) Occasionally withdraw the drill to clear the cuttings or chips.

(7) Apply a coolant or lubricant if necessary.

(8) Ease off on the pressure as the twist drill cuts through the stock to prevent splintering or grabbing.

Note: Scrap stock can be clamped to the back side of the material being drilled to prevent splintering and grabbing.

Note: When drilling large diameter holes, it may be necessary to drill a pilot hole first.

Transparency No. 12

10. Portable Sander-Grinder

a. Parts of the portable sander-grinder

(1)	Front handle	(7)	Handle
(2)	Abrasive disc	(8)	Power cord
(3)	Grinding guard	(9)	Air vents
(4)	Brushes	(10)	Housing
(5)	Switch lock	(11)	Rest
(6)	Trigger switch		

b. Uses of the portable sander-grinder

The portable sander-grinder can be used with an abrasive disc to shape and smooth metal or with a wire brush to clean surfaces. A sanding or polishing disc and pad can also be used for finishing wood or metal. The size of the disc is determined by its diameter, thickness, and arbor hole diameter.

c. Procedure for using the portable sander-grinder

(1) Select the correct disc for the job.

(2) Properly secure the disc on the arbor shaft.

(3) Check the disc for vibration.

(4) Secure the stock.

(5) Feed the disc lightly onto the work after the motor has reached full speed.

(6) Do not lay the sander-grinder down until the disc stops turning.

Transparency No. 13

11. Tilting-Arbor Bench Saw

a. Parts of the tilting-arbor bench saw

(1) Miter gage
(2) Rip fence
(3) Guide bar
(4) Fence clamp
(5) Fence micro-set knob
(6) T-slot for miter gage
(7) Switch
(8) Clean-out cover
(9) Saw guard
(10) Blade insert
(11) Table
(12) Tilt scale
(13) Raising handwheel
(14) Tilt handwheel
(15) Lock knob

b. Uses of the tilting-arbor bench saw

The bench or circular saw is used mainly for straight-edge cutting, which is ripping, crosscutting, mitering, beveling, dadoing, rabbeting, and chamfering. Other uses of this type of saw include the cutting of masonry material, sheet iron or thin steel, nonferrous metal, sanding, and the cutting of different types of molding. Special saw operations may include the cutting of dowels, cove cutting, and cutting bowl shaped objects. When using a circular saw to make special cuts, special saw blades must be used.

Bench or circular saw sizes are determined according to the maximum diameter blade that can be used on the saw. For example, an 8-inch blade will make a maximum square cut of 2½ inches, a 10-inch blade 3 3/8 inches, and a 12-inch blade 3 9/16 inches. A 45-degree angle cut using an 8-inch blade is 1 3/4 inches, a 10-inch blade 2 3/8 inches, and a 12-inch blade will cut a depth of 2½ inches. The bench saw is usually equipped with a 3450 rpm capacitor-start motor. Some of these motors have built in overload protectors.

Adjust the blade to approximately ¼ inch above material to be cut. The blade should be lowered below the table when not in use.

Transparency No. 14

c. Procedure for using the tilting-arbor bench saw

(1) Crosscutting

(a) A crosscut is considered to be at 90 degrees to the long edge of the board; therefore, check the miter gauge by setting it at "0". Place a framing square against the gauge and saw blade (square blade parallel with saw blade). Set the blade at a right angle to the table top for a square cut. If the board cuts are to be square, adjust the miter gauge if necessary. Make a trial cut with the saw blade at the proper height and check squareness with square and readjust if necessary. The stock should not touch the fence during this operation.

(b) To make the cut, hold the stock firmly against the miter gauge with one hand and push the miter gauge with the other hand. The body and both hands should be positioned on one side of the blade.

(c) When cutting long stock, attach a long piece of board to the miter gauge with screws or clamp in order to receive more support. Have a helper support only the end of the stock and move with the lumber (stock) as it is being pushed through the saw blade.

(d) Lift the lumber away from table after moving it away from the blade. Short pieces of waste material should be removed carefully away from a moving blade. If only one piece of stock is cut and the waste end remains on the table, wait until the blade stops turning before removing the waste piece.

(2) Ripping

(a) Set the blade at the proper height for cutting through the material and adjust tilt angle. The blade should be 90 degrees to the table for a square cut.

(b) The fence is self-aligning on most properly adjusted saws, but in case adjustment is necessary, check the distance on each end of the fence by using the table grooves as a guide and lock the fence down. If the fence is exactly parallel to the groove, it will likely be parallel to the blade for any desired width of cut.

(c) Set the fence for the width of cut by measuring from the fence side of the blade (tooth nearest fence) to the fence. This operation should be on the right side of the saw. Tighten the front fence lock to lock it down before making the cut.

(d) Assuming that the splitter is properly adjusted, lower the saw guard over the blade and adjust anti-kickback device if necessary.

(e) Use one hand to guide the stock against the fence and the other hand to push the stock into the blade at a steady rate. As the push hand approaches the fence, it may be safer to place two fingers over the fence to keep the hand away from the blade.

(f) Remove the stock and waste from the table very carefully. If one piece of stock is cut, it is safer to wait until the blade stops turning before removing waste.

(g) When ripping stock that is too narrow for safe finger clearance between the fence and saw, use a push stick to force the stock through the blade. Let the stock fall free or see that it is free of the blade before removing from the table.

(h) Use an assistant or roller stand to support the free end of long stock after it passes through the blade.

(i) To prevent saw kickbacks, hold the stock straight when feeding it through the saw, and feed the stock at a moderate rate. Most kickbacks are caused by binding, knots in lumber, dull saw blade, free-hand sawing, out-of-line fence, or feeding the material too fast through the saw.

Transparencies Nos. 15 and 16

(3) Making special cuts with the tilting-arbor bench saw

(a) Taper Ripping - Tapers can be cut by using two different methods. The most commonly used method is to place a marked stock against a jig that rests against the saw fence and push the jig and stock to the right of the blade and between the fence. The second method used to cut a taper is to mark the stock, tack it to a guide strip, and push the guide strip through the saw with stock attached.

(b) Beveling - Bevel cutting is made by tilting the blade or saw table at an angle up to 45 degrees. Ripping or crosscutting angles are made in the same way as straight ripping or crosscutting. The miter-gauge is used for most crosscutting and the fence for ripping bevels. All saws have a saw tilt scale that shows the degrees of tilt or angle. Chamfers are also made by tilting the saw blade to some degree angle, but the cut removes only one corner of the edge.

(c) Rabbeting - A rabbet cut is a notch cut out on the end or edge of boards. This cut can be made with a dado head or single blade.

When using a dado head to cut the edge of a board, an auxiliary fence (featherboard) should be attached to the saw fence. A featherboard may also be clamped to the table to take the place of the fence.

(d) Dado - A dado is a slot or groove cut into a board, usually for the insertion of another board. The dado cut is similar to the rabbet cut in that the blade or blades are never set up to cut completely through a board. This type of cut is generally made by using a dado head. It can be across or with the grain of wood; therefore, both the miter-gauge and fence are used to make cuts either across or with the grain. Chamfers are also cut with the dado head.

(e) Mortise and Tenon - A mortise is an opening (open mortise) made to accept a tenon. The open mortise can be made with saw blades and cutters. The blind mortise is made by using a mortising bit. A tenon is a cut on the end of a board that is inserted into a mortise cut. It is usually made by a dado head.

(f) Miters and Angles - The simple miter joint is made by setting the miter gauge at 45 degrees and making a cut flat or on the edge of board ends. The miter gauge can be set from 90 to 30 degrees in either direction. In order to make a square the gauge is set at 45 degrees. To get the correct angle for a six-sided figure the following procedure is used:

Divide 180 degrees by the number of sides (in this case 6), subtract the answer from 90 degrees, and use this figure (degrees) to set the miter gauge.

(180 + 6 = 30 90 − 30 = 60)

The miter gauge is set at 60 degrees to cut the six pieces.

Transparency No. 17

12. Radial Arm Saw

a. Parts of the radial arm saw

(1) Elevating handle
(2) Swivel latch
(3) Cantilever arm
(4) Yoke
(5) On-off switch
(6) Bevel latch
(7) Fence
(8) Bevel scale
(9) Kickback guard
(10) Miter scale
(11) Arm clamp handle
(12) Miter latch
(13) Circular column
(14) Self-adjusting blade guard
(15) Metal base

b. Uses of the radial arm saw

The radial arm saw has many of the same characteristics of the bench saw but differs in one important respect. The material being cut always remains stationary, while the saw itself moves. The radial arm saw is used mainly for straight-edge cutting, which is ripping, crosscutting, mitering, beveling, dadoing, rabbeting, and chamfering.

c. Procedure for using the radial arm saw

(1) Properly adjust the saw and select the correct blade for the job.

(2) Hold the material to be cut securely against the fence.

(3) Allow the blade to come to full speed before starting the cut.

(4) Have a firm grip on the handle and pull the blade, but do not force the saw cut.

(5) After completing the cut, shut off the power and do not leave the saw until the blade has completely stopped.

(6) Do not force the blade to stop with scrap materials.

Transparency No. 18

13. Vertical Band Saw

a. Parts of the vertical band saw

(1)	Guide post	(9)	Table clamp
(2)	Lamp	(10)	Ball bearing blade stop
(3)	Blade support lock screw	(11)	Blade guides
(4)	Blade guide lock screw	(12)	Table
(5)	Blade	(13)	Rear blade guard
(6)	Blade slot	(14)	Arm
(7)	Miter gauge groove	(15)	Blade guard
(8)	Table insert	(16)	Upper wheel guard

b. Uses of the vertical band saw

The main use of the vertical band saw is the cutting of curved surfaces, sometimes called contour cutting. It is equally well suited for straight cutting. Blades are available that can be used for cutting most all building materials. Common applications of the band saw are: trimming circles, cutting notches, and ripping.

The size of the vertical bandsaw is determined by the distance from the blade to the arm. Blades are selected depending upon length of the band, pitch of the teeth,

teeth per inch, type of metal, and width of the blade. The blade width determines the cutting radius. For example, a ½ inch blade has a cutting radius of 3/4 inch.

c. Procedure for using the vertical bandsaw

(1) Select the proper blade for the job.

(2) Properly adjust and tension the blade.

(3) Adjust the upper guard and guide about ½ inch above the material to be cut.

(4) Plan cuts to avoid "backouts" from curves.

(5) Lay out and make "release cuts" before cutting long curves.

(6) Start the cut only after the blade is moving at full speed.

(7) Keep fingers at least two inches from the blade and feed the stock at a steady, even speed.

(8) Do not force or twist the stock, causing stress on the blade.

(9) Turn off the machine before backing the blade out of a cut.

(10) A holding device should be used when making straight cuts or cutting round stock.

(11) Do not leave the machine until the blade stops and power is disconnected.

Transparency No. 19

14. Abrasive Cut-off Machine

a. Parts of the abrasive cut-off machine

(1) Motor
(2) Belt guard
(3) Wheel guard
(4) Feed handle
(5) Dust collector hose
(6) Dust collector
(7) Table
(8) Retractable size gauge
(9) Miter scale
(10) Abrasive wheel
(11) Stand
(12) On-off control
(13) Fence
(14) Work clamp handle
(15) 3-position work clamp

b. Uses of the abrasive cut-off saw

The abrasive cut-off saw is used to perform the same cuts as the metal hacksaw and metal bandsaw. The cut-off saw is used to make square and angle cuts on round, flat, and angular metal stock. The diameter of the abrasive wheel or disc determines the size of the abrasive cut-off saw.

c. Procedure for using the abrasive cut-off saw

(1) Select and properly install the correct abrasive wheel for the job.

(2) Adjust the cutting angle desired.

(3) Set the retractable size gauge for the desired cut-off length.

(4) Adjust the work clamp to secure the stock against the fence.

(5) A roller support stand or helper should be used to support long stock while cutting.

(6) Slowly bring the abrasive wheel in contact with the stock after full wheel speed is reached.

(7) Apply a steady, even pressure while cutting the stock.

(8) Do not leave the machine area until wheel stops and power is disconnected.

Transparency No. 20

15. Power Hacksaw

a. Parts of the power hacksaw

(1) Saw frame
(2) Vise
(3) Motor
(4) Crank-disk
(5) Connecting rod
(6) Cut-off gauge
(7) Reciprocating blade
(8) Switch
(9) Vise handle

b. Uses of the power hacksaw

The power hacksaw is used to cut square or angle cuts on any metal that is softer than the blade. The reciprocating (back and forth) blade will cut various thicknesses of metal, but is best suited for pipe or angle iron.

Blades are selected according to the length, thickness, width, kind of material in the blade, and teeth per inch. For example, a 12-inch blade may have 10 to 14 teeth per inch, be 1 inch wide, and be 0.050 inch thick. The blade is measured from the center of the holes.

Transparency No. 21

c. Procedure for using the power hack saw

(1) Mount the blade to cut on the power or forward stroke.

(2) Tighten the blade in the frame by using a torque wrench. Tighten the blade until a low ringing tone is heard when tapping it in the center with a hammer. A very high tone will indicate the blade is too tight, and a dull thud or tone will point out that the blade is not tight enough. In order to use a torque wrench, an instruction manual on the equipment must be available. Do not start a new blade in an old blade slot, because it may bind and break.

(3) Place the metal stock in the hacksaw vise. Measure the stock from the saw blade outward. The vise is located on the other side of the blade, and this portion is not the measured part of the stock. Several pieces of the same length can be cut by using the cut-off gage. Different shapes of stocks must be held in the vise in different positions.

(4) Let the blade down on the stock by hand and start the motor. If the saw is wet cutting, check the fluid flow. Set the feeding pressure (forward stroke) by adjusting the pressure knob. High carbon steel is cut at a slower speed than low carbon steel. Keep the blade lubricated for most metals. The saw should stop automatically after cutting through the stock.

Transparency No. 22

16. Metal Cutting Horizontal Band Saw

a. Parts of the horizontal band saw

(1)	Head	(8)	Hydraulic feed control
(2)	Blade tension knob	(9)	Table
(3)	Blade guard	(10)	Automatic shut-off switch
(4)	Blade	(11)	Motor switch
(5)	Blade pulley guard	(12)	Adjusting hand wheel
(6)	Stationary blade guide	(13)	Adjustable vise jaw
(7)	Stationary vise jaw	(14)	Adjustable blade guide

b. Uses of the horizontal band saw

The horizontal band saw is used for the same purpose as the power hacksaw, but differs in that it has a continuous blade. The blade in this type of band saw moves faster with more cutting precision and less cutting waste than the power hacksaw. The teeth are set in two different ways, raker set or wavy set, and the tooth pattern may be standard, skip, or hook tooth. The standard tooth has more teeth per inch and is better for cutting ferrous metals. The skip tooth is used to cut alluminum, copper, soft brass, and magnesium metals. The hook tooth blade

cuts nonferrous metalllic materials. This blade does not gum up like a standard blade due to the design of the chip breaker.

c. Procedure for using the horizontal band saw

(1) Turn the idler wheel tension screw until the blade will slide on the wheels and in the center of the roller guides. Be sure that the blade teeth point in the direction the blade is to turn, which is downward. Tighten the blade on the wheels and continue to tighten after the motor is running. If the blade slips while cutting, it should be tightened. Adjust the blade so that it will ride in the center of the wheels. It should cut true and square. Guide adjustment usually keeps the blade in place. Wheel adjustment tightens or loosens the blade.

(2) Mark the stock for cutting and place it in the vise and tighten. Set the angle of the saw with the aid of a square.

(3) Set the cut-off gage if more than one piece of stock is to be cut. Use a stock support or sawhorse for long pieces of stock.

(4) Lower the blade to the stock but hold it clear until the saw is running. Make a small kerf and remeasure the length of stock. Restart the motor for making the cut. The cutting fluid should be flowing at this point. If the blade attachment is equipped with blade brushes, keep brushes clean and angled in the same direction the blade travels.

(5) Operating the power hacksaw and horizontal band saw require similar procedures. For example, the proper blades must be selected for the job, the type of cut selected (90-degree or some other angle), speed and pressure of cut regulated, and the stock properly placed in the vise.

d. Operational problems, possible causes, and suggested procedures to correct problems

(1) Cutting Out of Line

(a) Feeding too fast and worn blade
(1) Reduce feeding or replace the blade.
(2) Replace worn guide bearings when they begin to show excessive wear.

(b) Guides in wrong position
(1) Set guides as close to work as possible.
(2) Align guides properly.

(c) Teeth worn on side of blade
(1) Avoid teeth rubbing in cut by applying enough weight so that each tooth is cutting a good chip.

(2) Keep blade brushes clean.

(d) Starting cuts on odd shaped metal
(1) Shaped corner material (angle iron) can be grounded or filed slightly to form a flat cutting surface. Retard feed of blade on a flat surface until it has a good start into the material.

(2) Stripping Teeth

(a) Blade teeth too coarse
(1) Be sure at least 2 or 3 teeth are in contact with the material being cut.
(2) Start blade slowly using proper pressure on thin material.

(b) Hard spots being cut in material
(1) Rotate stock if possible while cut is being made. Avoid putting a new blade in an old cut at the same angle.

(3) Breaking and Twisting Blade

(a) Guides out of alignment
(1) Check guides to see that they hold the blade in line both vertically and horizontally.
(2) Check instructions and make adjustment.

(b) Blade twisting
(1) Hold materials firmly at all times while it is being cut.
(2) Set the guides as close to work as possible.
(3) Keep blade tight while the saw is in use.

(4) Excessive Blade Wear

(a) Blade does not remain sharp
(1) Blade speed may be too fast.
(2) Tension may be set too loose.

Transparency No. 23

17. Jointer

a. Parts of the jointer

(1) Rear outfeed table
(2) Fence
(3) Cutterhead guard
(4) Front infeed table
(5) Fence control
(6) Tilt scale
(7) Front table adjusting wheel
(8) Depth scale
(9) Base
(10) Rear table adjusting wheel

b. Uses of the jointer

The jointer usually has a three-knife cutter head and will make several thousand knife cuts per minute. The jointer is used primarily to straighten the edge of lumber. Straightening the face of lumber is called facing. Straightening the edge of lumber is called jointing. Other uses of the jointer are: beveling, chamfering, tapering, and rabbeting. The length of the cutter head knives determines the size of the jointer. The most common size is a 6-inch jointer.

c. Procedure for using the jointer

(1) Properly adjust the knives, infeed table, and outfeed table. The rear outfeed table should be exactly level with the knives in the cutterhead.

(2) The depth of cut is adjusted with the front table adjusting wheel. Adjust the machine to cut no more than 1/8 inch for softwoods and 1/16 inch for hardwoods.

(3) When knives are to be replaced or sharpened, do so as a set, due to the necessity of keeping them in balance.

(4) Adjust the fence depending on the job to be done. Move the fence to different positions in relation to the cutterhead so as not to cut in the same place all the time.

(5) Check the grain of the lumber and cut only with the grain.

(6) Use a push stick for short stock and a roller support stand or helper for long material.

(7) Stand out of line with the tables and feed the lumber slowly into the jointer (16 feet per minute). Be sure cutterhead is at full speed before use.

(8) Do not attempt to joint stock less than ¼ inch in thickness or shorter than 12 inches in length.

(9) Make sure the stock is held firmly against the fence and table.

(10) Do not leave the machine area until the cutterhead has stopped and power is disconnected.

Transparency No. 24

18. Planer

a. Parts of the planer

(1)	Feed roll adjustment	(7)	Elevating hand wheel
(2)	Chip guard	(8)	Variable speed feed control
(3)	Pressure bar adjustment	(9)	Feed motor housing
(4)	Table bed	(10)	Cutterhead motor
(5)	Bed roll adjustment	(11)	Depth cut gauge
(6)	Hand wheel lock	(12)	Motor switch

b. Use of the planer

The planer is designed to machine stock to exact thickness. The planer has a cutterhead equipped with knives and is similar to the jointer except that it cuts from the top. The planer is sized according to the cutterhead width; usually 12, 18, or 24 inches. The planer is equipped with four rollers, two upper and two lower. The upper rollers are designed to feed and pull the stock through the machine. The chip breaker prevents the knives from chipping the board. The pressure bar keeps the stock down against the table to get a uniform cut and finish.

c. Procedure for using the planer

(1) Adjust the depth of cut (no more than 1/16 inch for hardwoods or 1/8 inch for softwoods).

(2) Adjust the feed roll speed (up to 45 feet per minute for softwood and 15-25 feet per minute for hardwoods).

(3) Allow the motor to gain full speed.

(4) Stand to the side of the machine.

(5) Use a helper or support stand for long stock. Do not plane stock less than 12 inches in length.

(6) Feed the stock at right angles to the cutterhead.

(7) Do not force the stock, allow the feed roll to pull the material. (Plane with the grain).

(8) Use a backer board for lumber less than 3/8 inch thick.

(9) Remain in the machine area until the machine stops and power is disconnected.

Transparency No. 25

19. Abrasive Belt-Disc Sander

a. Parts of the abrasive belt-disc sander 221

(1) Belt tension knob
(2) Lock knob
(3) Disc guard
(4) Abrasive disc
(5) Tilting table
(6) Miter gauge
(7) On-off switch
(8) Motor housing stand
(9) Lock knob
(10) Dust spout hose
(11) Tilting table
(12) Abrasive belt
(13) Belt guard

b. Uses of the abrasive belt-disc sander

The abrasive belt-disc sander is used to sand or shape edges and end grain of stock. The size of the machine is determined by the diameter of the disc and the width of the belt. The revolving disc or belt moves past a stationary table that can be adjusted for sanding at various angles. In sanding, the work should be done on the down side of the disc or belt. The belt sanding unit can be adjusted to operate either in a vertical or horizontal position.

c. Procedure for using the abrasive belt-disc sander

(1) Select and properly adjust the correct disc and/or belt for the job.

(2) Adjust the table to the proper angle for the job and allow approximately 1/8 inch clearance between the table edge and the belt or disc.

(3) Allow the motor to reach full speed and carefully move the stock into the disc or belt with enough pressure to maintain the cutting operation.

(4) Move the stock sideways, back and forth slightly to reduce the heat caused by friction.

(5) Remove the stock when the job is completed, turn off the motor, and do not leave the machine area until the motor stops and power has been disconnected.

Transparency No. 26

20. Drill Press

a. Parts of the drill press

(1) Motor
(2) Head support safety collar
(3) Pilot wheel feed
(4) Table locking clamp
(5) Column
(6) Belt and pulley guard
(7) Variable speed pilot wheel
(8) Switch
(9) Depth stop
(10) Quill lock
(11) Key chuck
(12) Tilting angle scale
(13) Tilting table
(14) Lower table or base

b. Uses of the drill press

The primary purpose of a drill press is to drill holes, but it has many more functions in the agricultural shop. With appropriate attachments some drill presses are used to cut mortises and rabbets; and to grind, sand, buff, polish, rout, and shape many building materials.

Drill press size is determined by the diameter of a circular piece of material that is drilled through the center while still on the drill press table, or, expressed in another way, the distance from the column to the center of the drill. Some common sizes of drill presses are 11-inch, 15-inch and 17-inch. Most drill presses are equipped with ½ -inch chucks and range in speeds between 400 and 8500 rpm. The slow speed presses are used to drill in metal, and high speed presses are used for drilling wood. Many of the more modern types are built with varying speeds, usually from two to eight. Speeds can be changed on the belt-pulley type by changing the pulley-belt ratio. A good speed to run the standard type press is about 1725 rpm. A standard motor may vary in size from 1/3 to 1/2 hp.

Transparencies Nos. 27 and 28

c. Procedure for using the drill press

(1) Drilling wood

(a) Mark the stock at the point of the center of hole to be drilled and make an impression at this point to prevent the drill point from crawling. The indent is especially needed when drilling hardwood with a twist drill.

(b) Use clamps or other hold down devices to prevent the stock from moving. C-clamps are usually used to hold wood firm on the drill table. If possible align the center hole in the drill table with the bit before clamping stock to table. If stock is held by the hands it may cause injury. A V-block should be used to hold round stock.

(c) Use an even, steady pressure on the feed handle to drill holes. The pressure should be reduced at about the break - through point. The two methods to prevent a break-through and the stock from splintering are the use of backing lumber under the hole location while drilling or reversing the stock as soon as the point breaks through and placing the bit point in the point hole to finish drilling. The feed stop should be set to prevent the point from breaking through on the initial cut. This operation is easier when using spur bits.

(d) When boring to a certain depth, the piece of material (stock) should be pushed against the bit, the bit brought down to the mark, and the depth or feed stop set at this point. The quill should be locked while making

the adjustment. This same procedure is followed when setting a countersink or counterbore.

(e) When boring deep holes, the bit may become clogged with wood shavings and overheat; therefore, the bit should be removed from the hole repeatedly to be freed of chips. This is a very important operation step when using a wood twist drill.

(f) When boring large holes use either a power wood bit (up to about 1½ inch), hole saw (to about 3 inches), expansive bit (up to about 3 inches), or a circle cutter (up to 8 inches). All these bits except the power wood bit should be operated at a slow speed. The circle bit will function better at speeds below 500 rpm.

(g) In order to make a mortise cut for a mortise and tenon joint, use a mortise chisel attachment and mount it on the non-revolving quill which is located above the revolving spindle. The hollow chisel is square in sizes ¼, 3/8, and ½ inch. As the bit turns and the chisel is forced into the stock, a square hole is formed. The drill speed should be between 3600 to 3800 rpm for this operation.

(2) Drilling metal

(a) Determine the center of the hole and mark it with a center punch to keep the drill from crawling.

(b) Clamp small stock in a drill press vise (general purpose, angle, rotary indexing table, or unversal compound vise). A strap clamp for flat stock and V-block for round material are recommended for small stock. V-blocks are sometimes used with Y-clamps. C-clamps and angle iron also make good stock supports, especially if the metal is irregular in shape. Parallels and strap clamps are fastened to the table with special fasteners.

(c) Use a good grade of cutting oil while drilling. It cools cutting lips and stock, lubricates chips, improves the finish of holes, and lengthens the life of drills. Kerosene can be used on dense aluminums. Some nonferrous metals are drilled without the use of oil.

(d) Drilling metal is similar to drilling wood in that a steady, even pressure is applied until the bit begins to break through the metal when drilling holes. Most ferrous metals will produce ribbons or rolled chips, instead of small chips, if proper pressure is applied. Chips will appear when drilling cast iron.

(e) Countersinking and counterboring are also similar to these practices used on wood stock. Both countersinking and counterboring permit

the fastener head to be recessed below the surface. A machine screw countersink is 82 degrees, and the drill is operated at the same speed as when drilling holes. The following procedure is used: set feed stop so that head will be flush with the surface. Counterboring is drilling or cutting an enlarged area to recess bolt heads. In this case the feed stop is set so that the lips of the bit cut deep enough to seat the entire depth of the bolt head. Drill the fastener hole before attempting to use either the countersink or counterbore.

(3) Other Drill Press Uses

(a) Reaming and Lapping - Reaming is the removing of a small amount of metal to make a hole the exact size. Lapping is done with a rod and abrasive. It is more like polishing than cutting metal.

(b) Plastic and Glass Drilling - Special bits are used to drill both plastic and glass. Plastic holes should be slightly oversize. Glass is drilled with either a diamond-pointed or tungsten-carbide-pointed bit. Glass is placed on a flat surface and the proper amount of pressure is applied, and kerosene, water, or turpentine is used as a lubricant while drilling.

(c) Metal Finishing and Shaping - There are several different types of shaping, deburring, and grinding points used to shape and finish metal. Cutters and grinders are used to shape metal, plastic, and wood. The quill is locked at the proper height, and the stock is pushed against the cutter or grinder lightly. The quill is also locked in the proper position when using wire brushes or buffers.

Transparency No. 29

21. Grinder

a. Parts of the grinder

(1) Motor
(2) Adjustable spark deflector
(3) Wheel guard
(4) Plane iron grinding attachment
(5) Dust chute
(6) Pedestal
(7) Safety guard
(8) Grinding wheel
(9) Water container
(10) Adjustable tool rest
(11) Switch

b. Uses of the grinder

The major purpose of a power grinder in any shop is to maintain the many types of cutting tools. Most cutting tools and equipment have tempered cutting edges; therefore, cutting edges can be conditioned only with the grinder. Grinders are used not only to sharpen tools, but also to shape metal such as smoothing a weld joint, polishing, cleaning rusty or corroded metal, and even sanding. Special

wheels are used to sharpen certain types of saw blades; shape the web of a twist drill; polish metals, plastics, and wood; buff many types of materials; and sand plastic or wood. Also, special wheels are used to sharpen sickle mower blades.

There are two kinds of abrasive wheels used on the general-purpose grinder; the aluminum oxide and the silicon carbide. Bauxite clay is fused with aluminum oxide in an electric furnace to form a very tough abrasive for grinding steel, malleable iron, and bronze. When coke and sand are fused together silicon carbide is formed. This is a hard brittle abrasive used to grind cast iron, aluminum, copper, bronze, and non-metallic materials.

When selecting a stone for the grinder, the diameter, width, size of arbor hole, rpm of the grinder, and grit must be given. Grit is the number of cutting particles per linear inch. For example, a 60 grit wheel has 60 cutting particles per inch or 3,600 per square inch.

Stone or wheel grit size and uses are:

(1) Fine wheel (100 to 120 grit) should be used for grinding wood chisels, plane irons, butcher knives, and other fine cutting edges.

(2) Medium wheel (60 grit) should be used for grinding hatchets, smoothing welded areas, and sharpening heavy chisels.

(3) Coarse wheel (20 to 30 grit) should be used to grind cast iron and heavy iron castings.

The grade of a wheel is determined by its hardness or softness. Soft wheels will not draw the temper from edge tools as fast as a hard grade wheel, yet wheels that are too soft shed particles of grit too fast, become out of shape, and wear out in a short period of time. A good grade stone or wheel sheds the particles of dull grit gradually and exposes sharp particles for cutting.

Transparencies Nos. 29 and 30

c. Conditioning the grinding wheel

(1) If the grinding wheel face becomes rounded (one side lower than the other) or glazed due to grinding soft metals, a grinding wheel dresser should be used to restore the proper shape or remove the soft metals. The abrasive action is reduced if the wheel is glazed and this condition causes the tool being sharpened to overheat.

(2) Steps in using a grinding wheel dresser are:

(a) Set the tool rest in line with the wheel and about 1/8 inch away from the wheel face.

(b) Place the tool dresser on the tool rest, holding the handle with both hands and parallel to the floor.

(c) Place about one-half of the cutters on the revolving wheel and move the dresser from one side of the wheel to the other until the glaze is removed or wheel is true. Care should be taken to keep the cutter or dresser handle in line with the side of the wheel.

(d) Check the squareness of the cutting surface or wheel face with a combination or try square.

Transparencies Nos. 30 and 31

d. Procedure for using the grinder

(1) When grinding work pointed at the center of the wheel, level the tool rest and set it just below the wheel center. This position is usually used for general shaping work and work that requires a square edge. When grinding above or below the center of the wheel, a bevel will be formed on the material. The square method is used for jointing edge tools (removing nicks). The tool rest should be set level with the center of the arbor shaft and about 1/8 inch from the wheel.

(2) It may be necessary to do some freehand grinding without the aid of a tool rest. To do this type of grinding hold the material below the center of the wheel and move it evenly across the face from left to right and right to left. The tool rest is not usually used when grinding hatchets or axes due to the grinding position being high above the center of the wheel. The hatchet is moved back and forth and up and down (about 5/8 inch) to cut the bevel.

(3) When grinding plane irons, wood chisels, and other edge tools that are hollow ground, it is best to set the tool rest at an angle to grind the proper bevel. The bevel of these two cutting tools is about 30 degrees. A tool holder may be used to sharpen a plane iron or chisel. The holder is usually mounted (attached) to the tool rest. Regardless of the method used to hold the tool, it must be constantly moved on the wheel to prevent overheating and improper cutting. Up and down movement is only used when shaping such tools as screw drivers, hatchets, axes, and other tools with large bevels. The cutting blade is worked from one edge of the wheel face to the other. Sharpen cold chisels by either setting the tool rest at an angle or leaving it level. The rest may be used only as a starting support for the finger when sharpening a twist drill.

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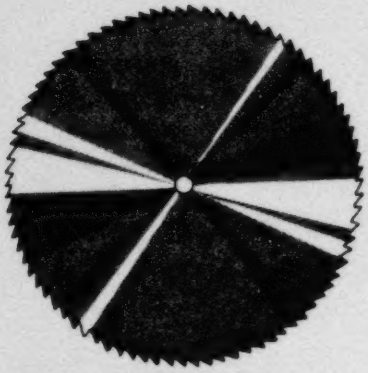
6. "Developing Shop Safety Skills", American Association For Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1978.

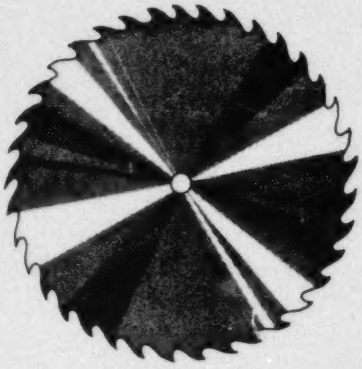
7. "Power Tool Know How", Sears, Roebuck and Co., 1975.

8. "Power Tool Safety and Operation", Hobar Publications, St. Paul, Minnesota, 1973.

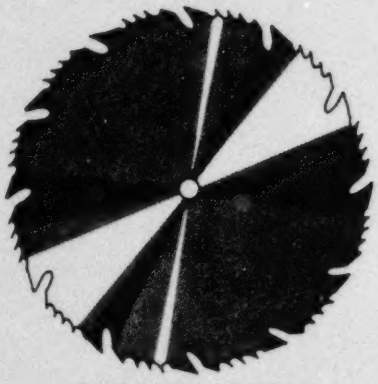
CIRCULAR SAW BLADES



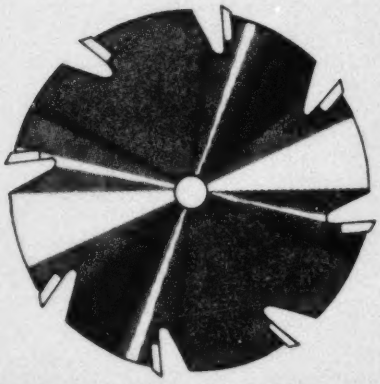
CROSSCUT



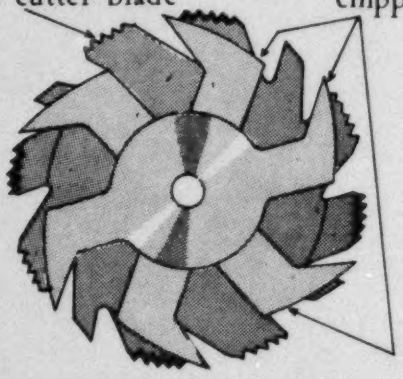
RIP



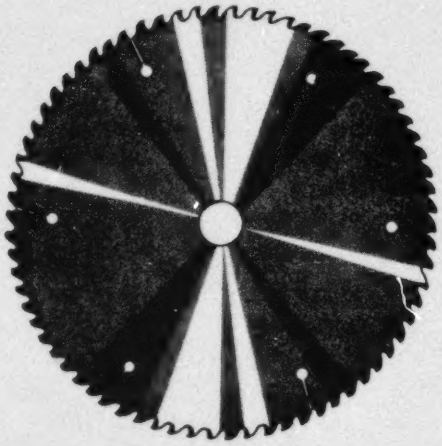
COMBINATION



CARBIDE-TIPPED COMBINATION



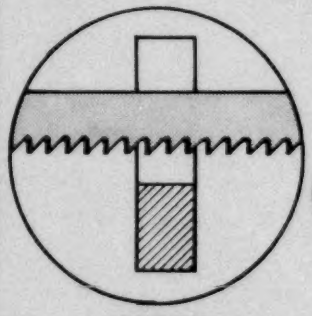
DADO HEAD
(nearest cutter blade removed)



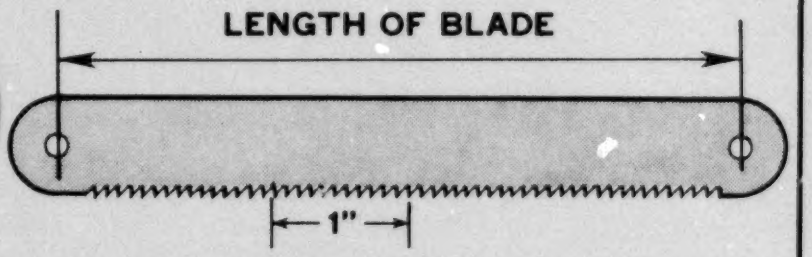
CARBIDE-TIPPED WOODCUTTING

OTHER SAW BLADES

HACKSAW & BAND SAW



3 TEETH
IN CONTACT
WITH STOCK

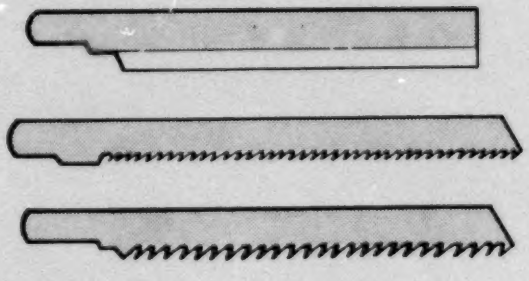


12 TEETH=13 POINTS

RAKER SET

WAVY SET

SABRE SAW

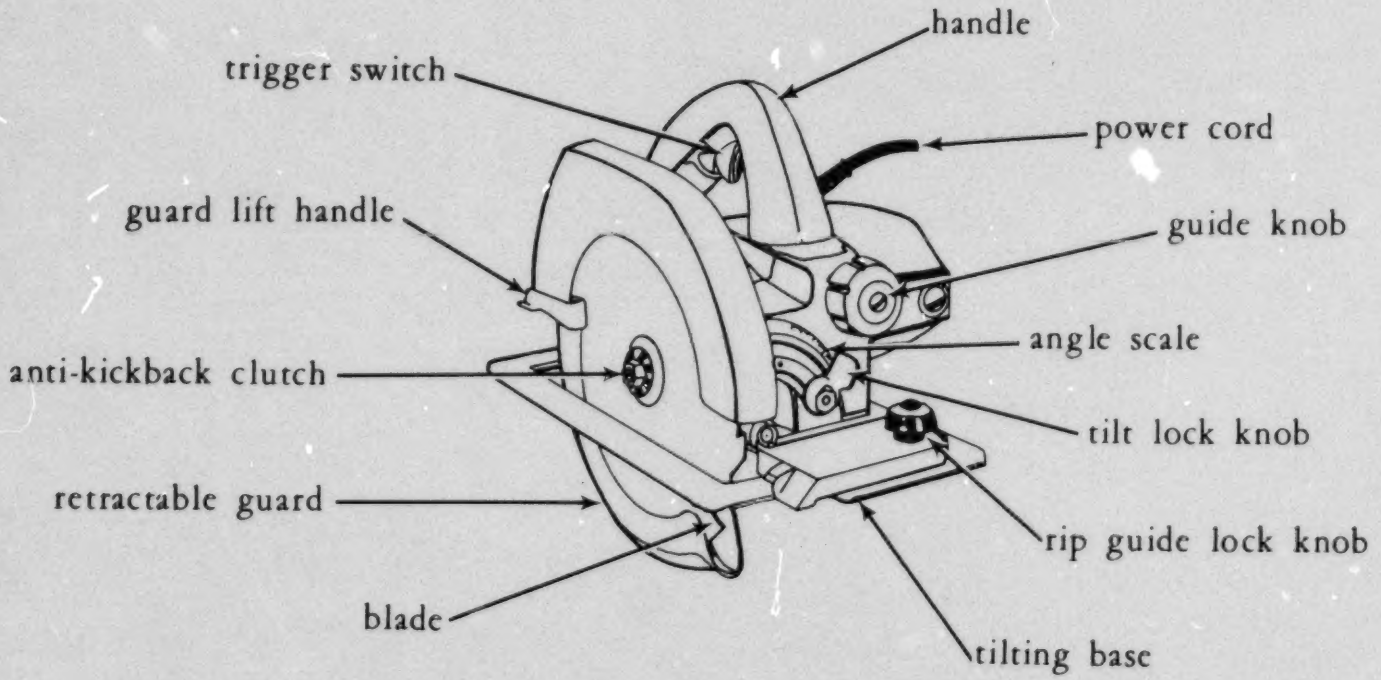


KNIFE

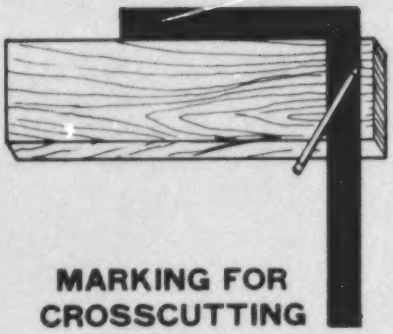
METAL CUTTING

WOOD CUTTING

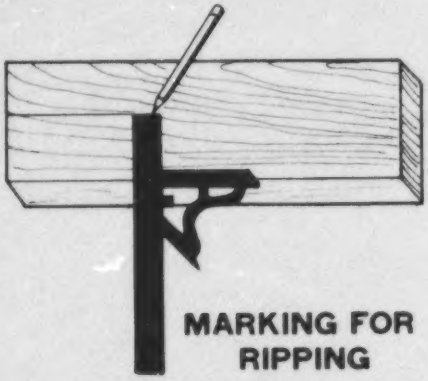
PORTABLE CIRCULAR SAW



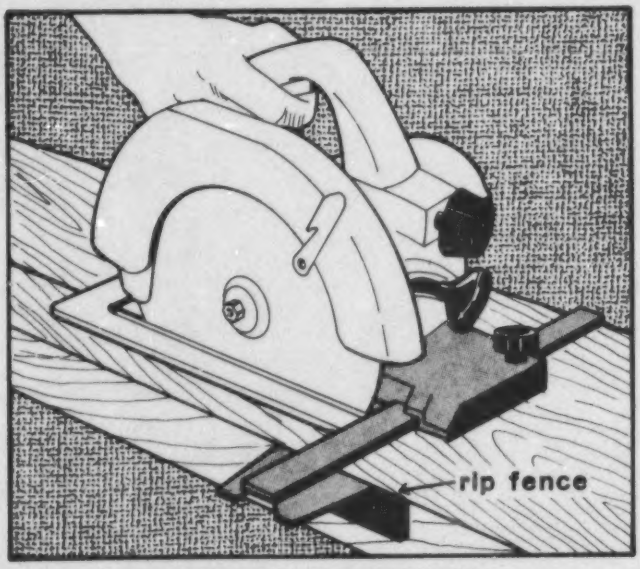
OPERATING THE PORTABLE ELECTRIC SAW



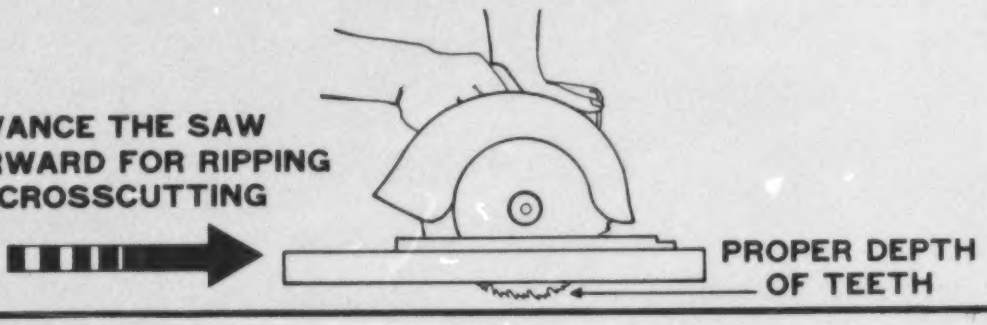
MARKING FOR CROSSCUTTING



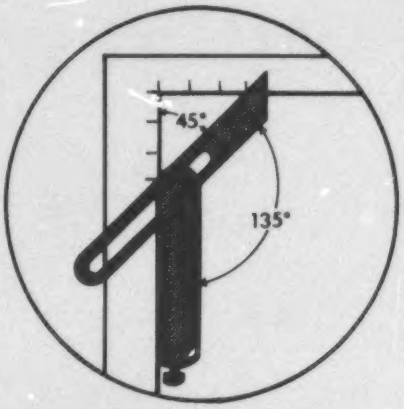
MARKING FOR RIPPING



USE OF RIP FENCE

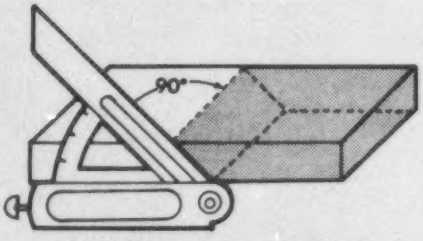


OPERATING THE PORTABLE ELECTRIC SAW



SETTING T-BEVEL SQUARE AT 45°

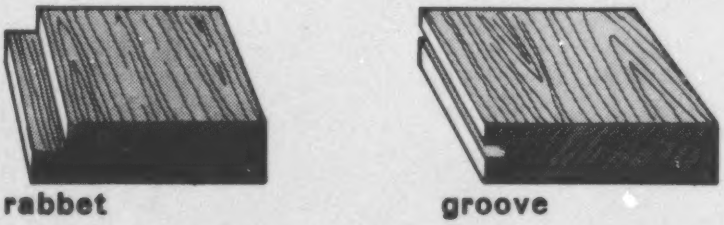
MARKING MITER



MARKING BEVEL

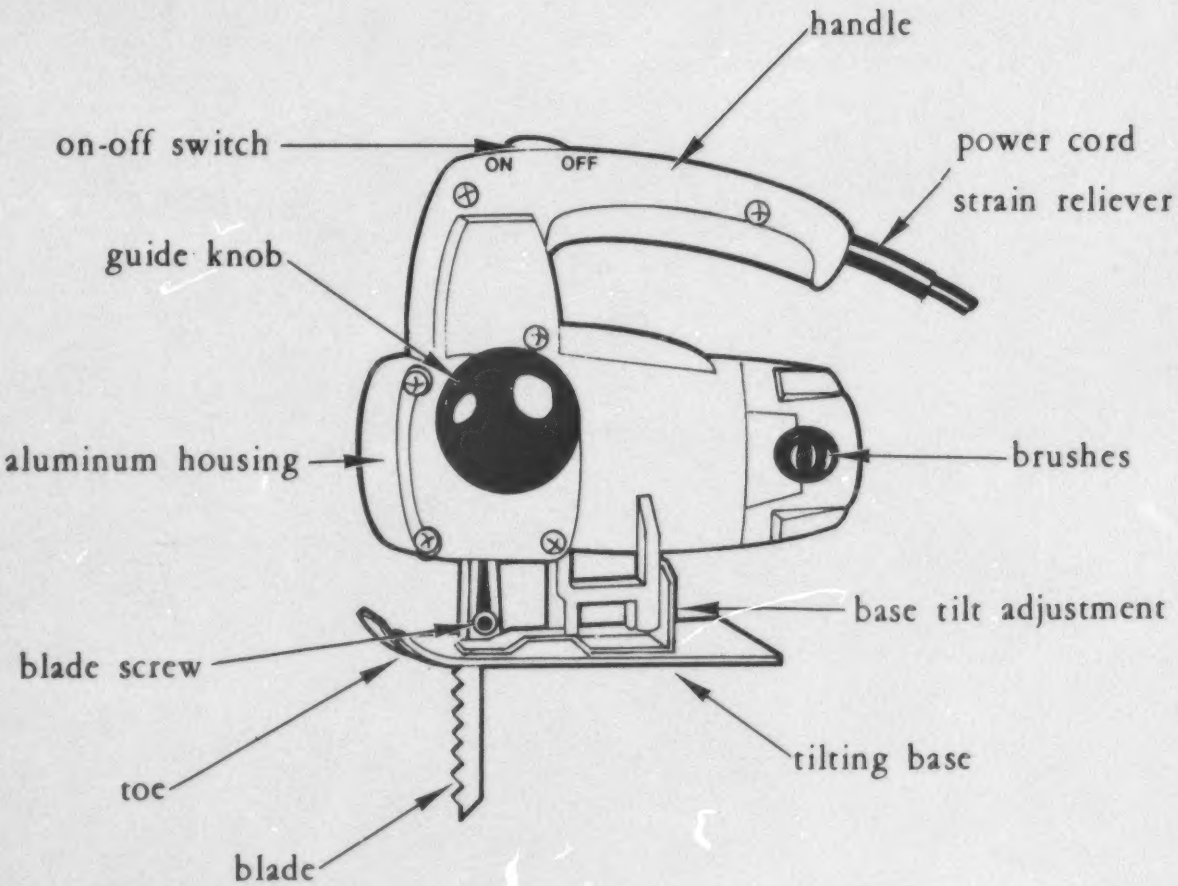
COMBINATION BEVEL

CUTTING DADO

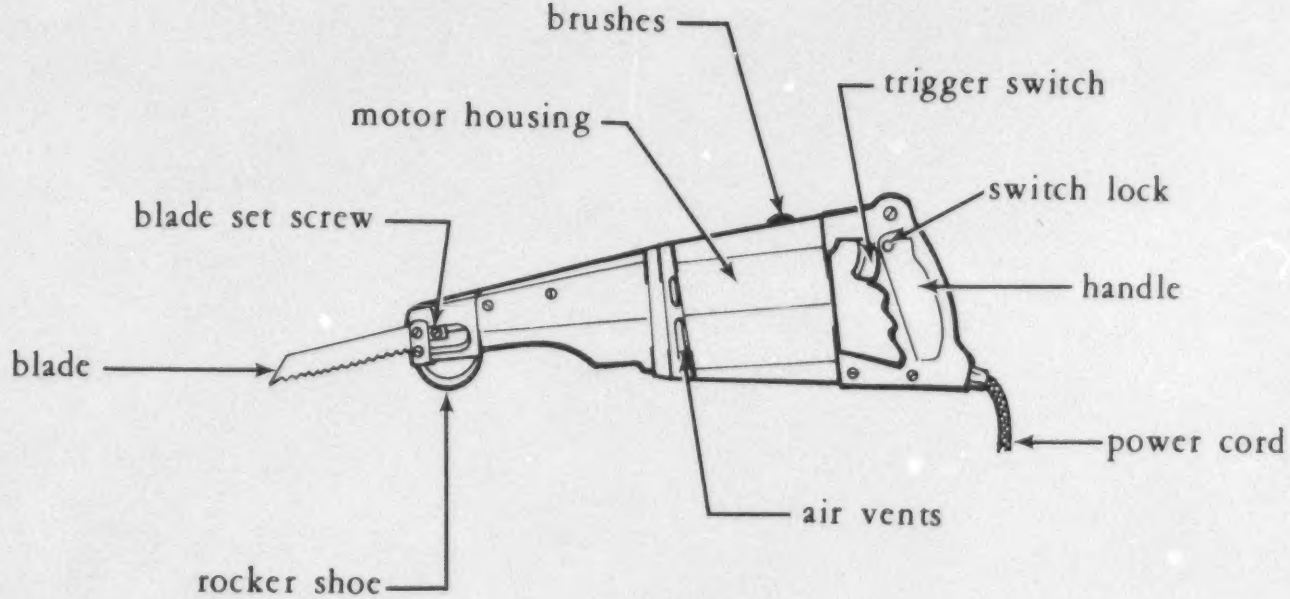


CUTTING RABBET

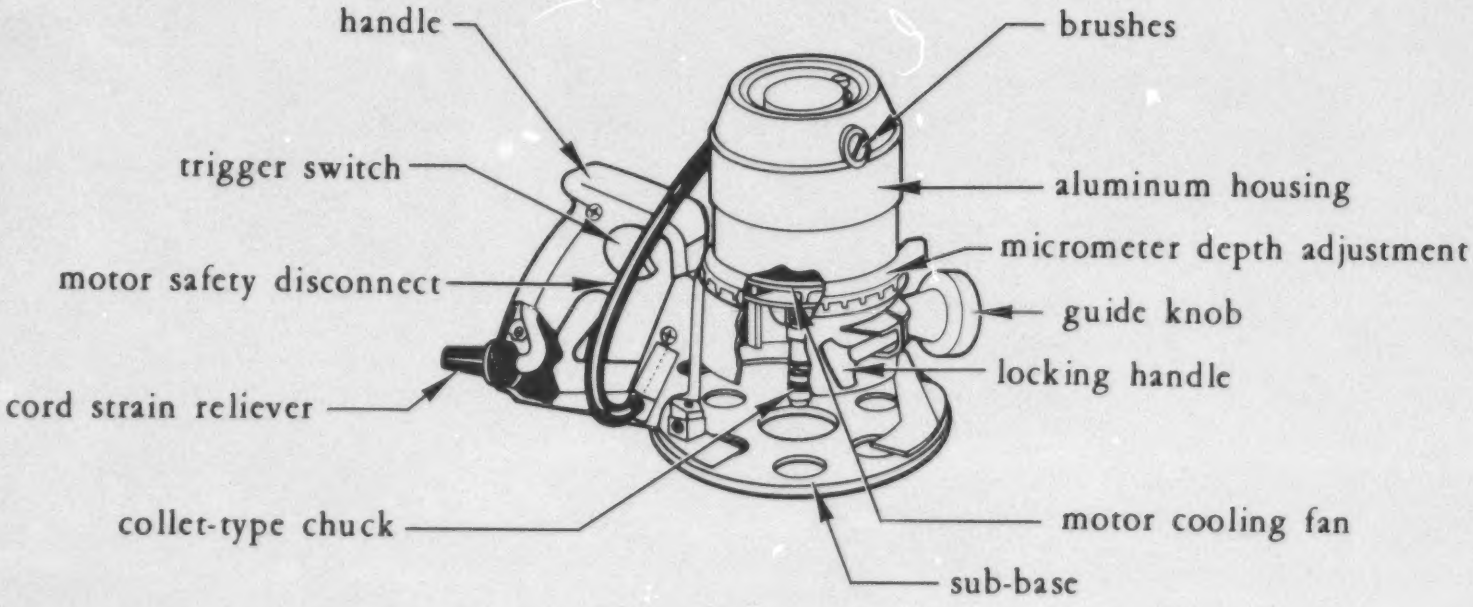
SABRE SAW


handle
on-off switch
ON
OFF
power cord
strain reliever
guide knob
aluminum housing
brushes
base tilt adjustment
blade screw
toe
tilting base
blade

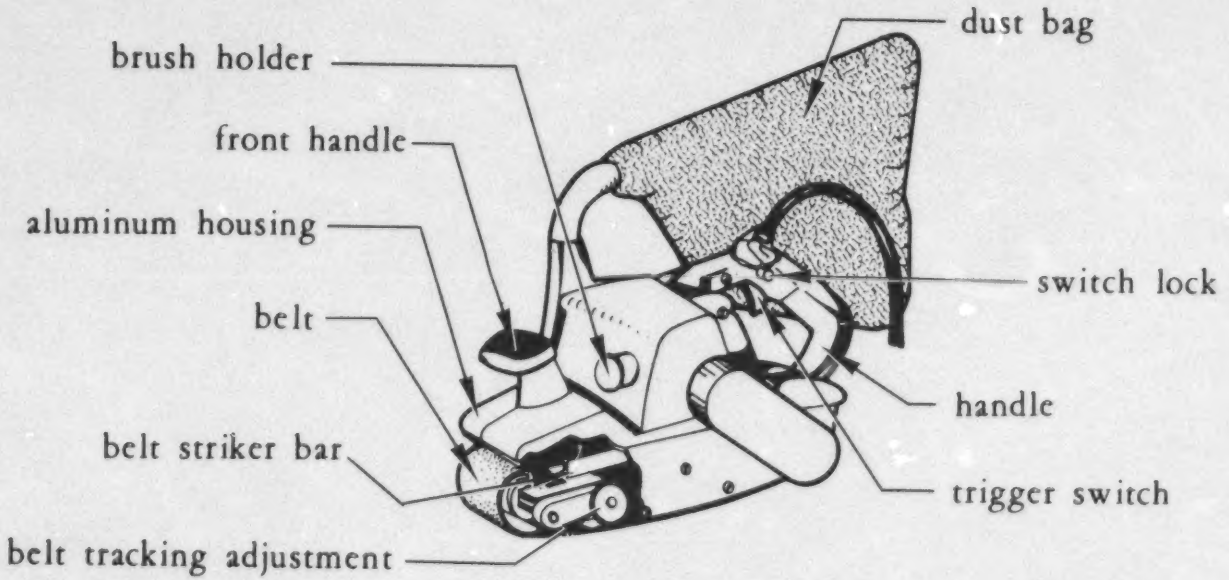
RECIPROCATING SAW



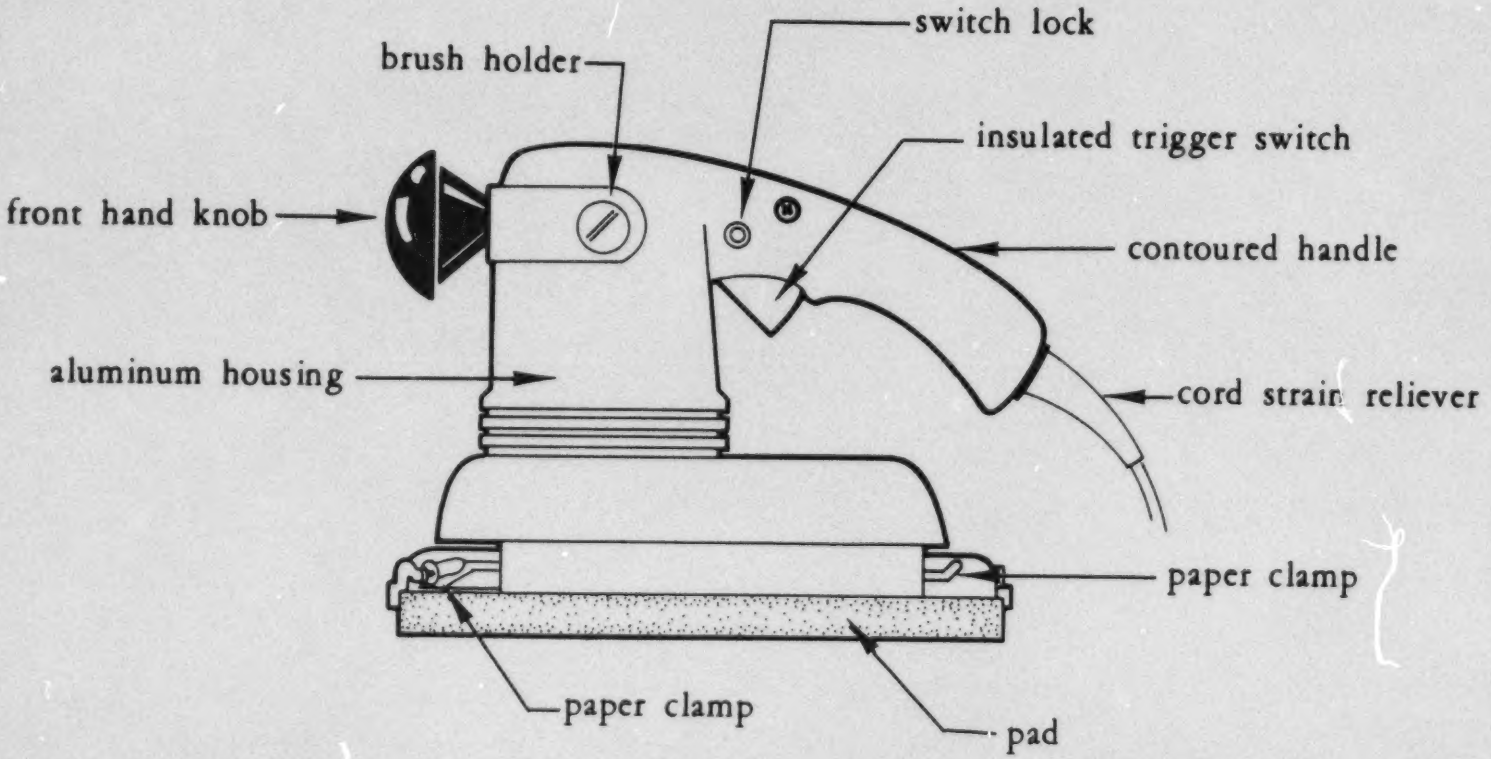
ROUTER


handle
brushes
trigger switch
aluminum housing
micrometer depth adjustment
motor safety disconnect
guide knob
locking handle
cord strain reliever
collet-type chuck
motor cooling fan
sub-base

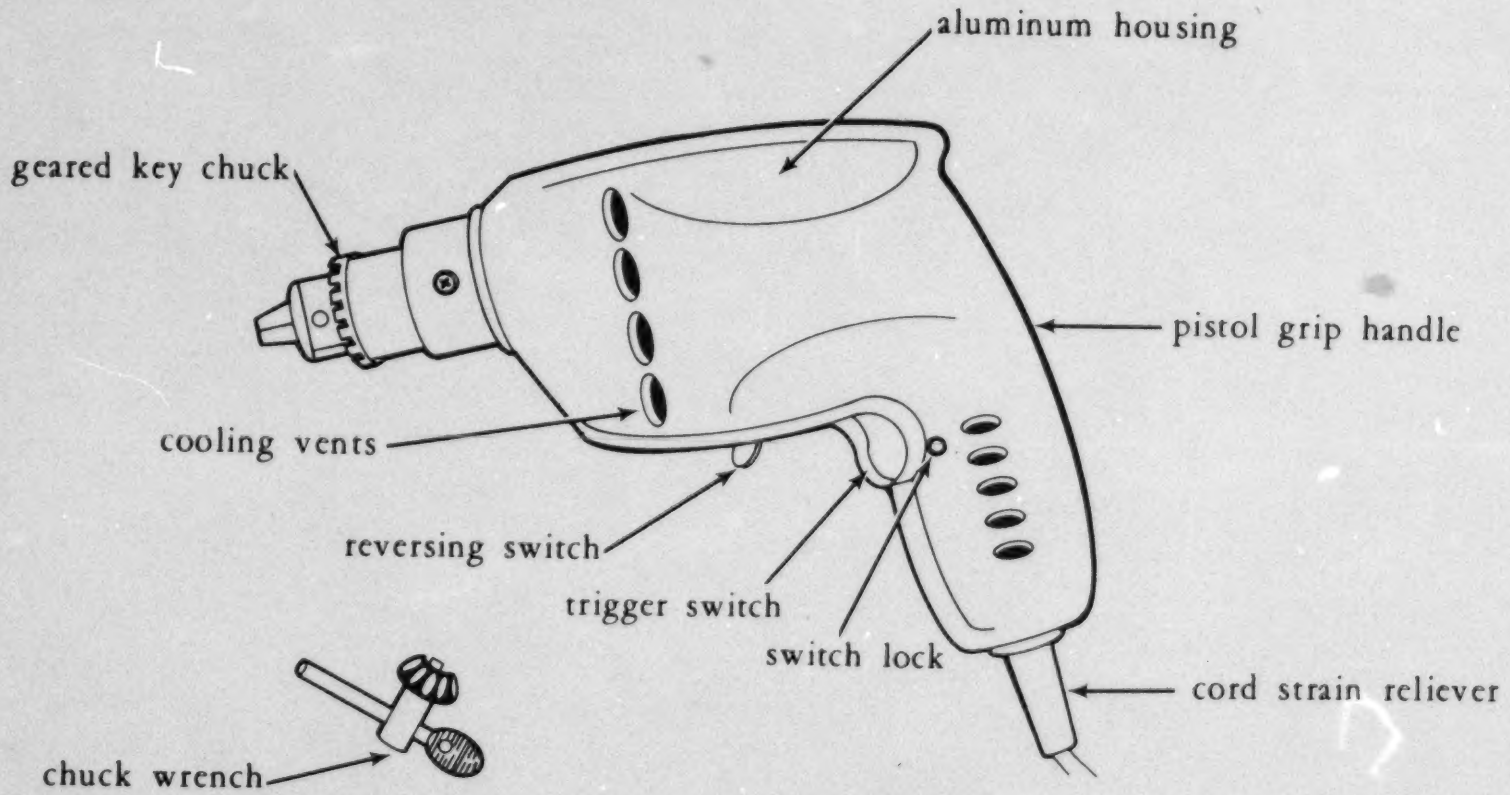
PORTABLE BELT SANDER



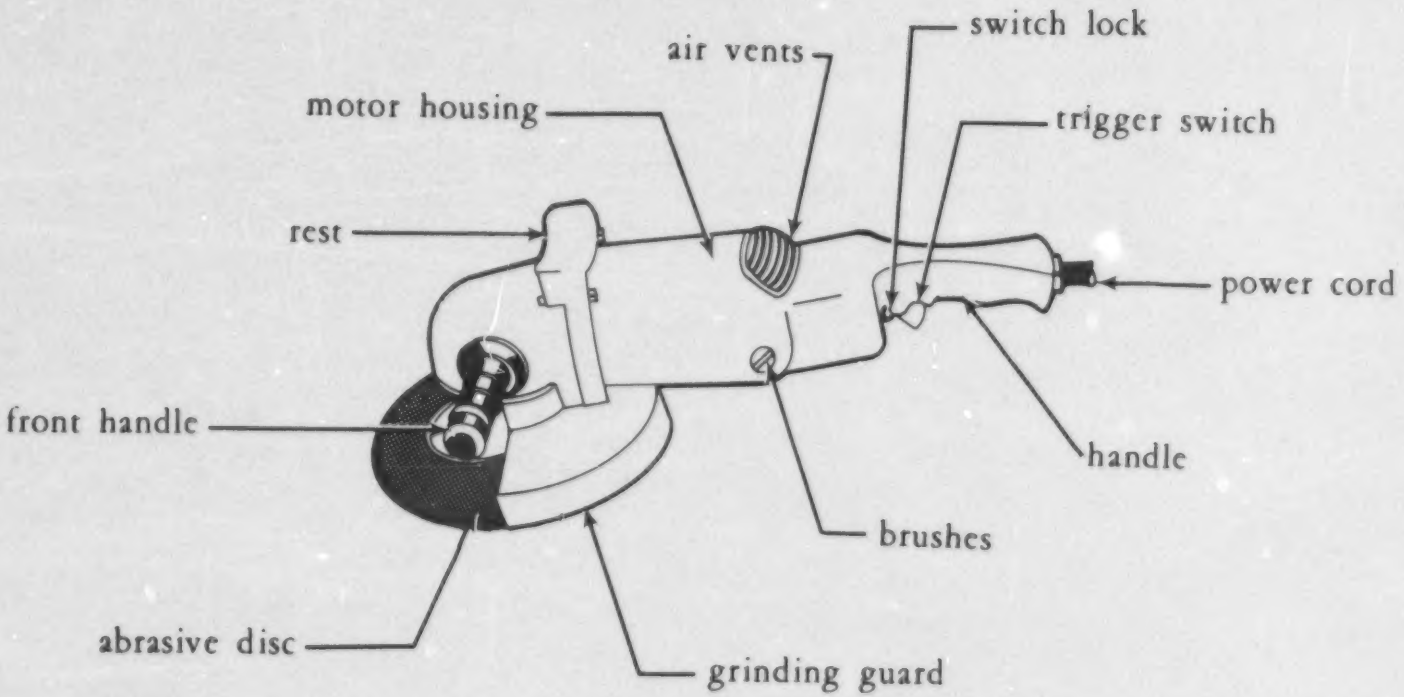
FINISHING SANDER



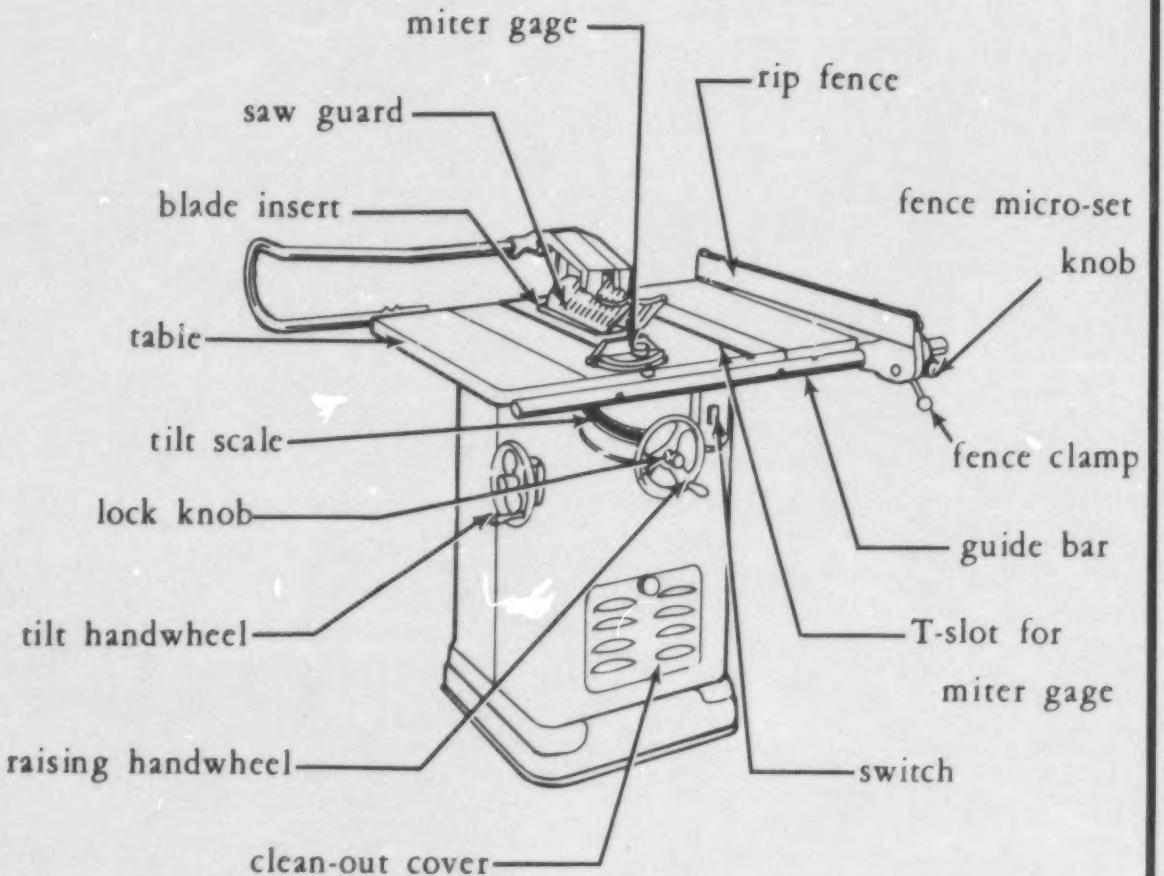
PORTABLE DRILL



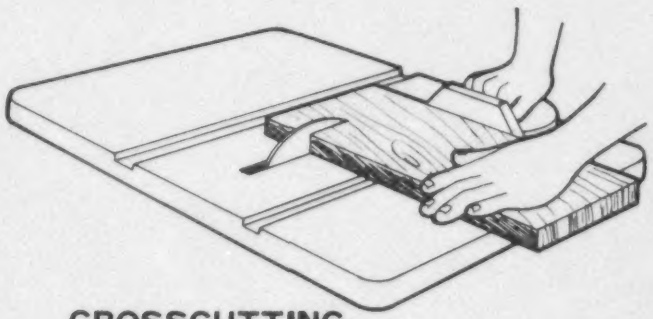
PORTABLE SANDER-GRINDER



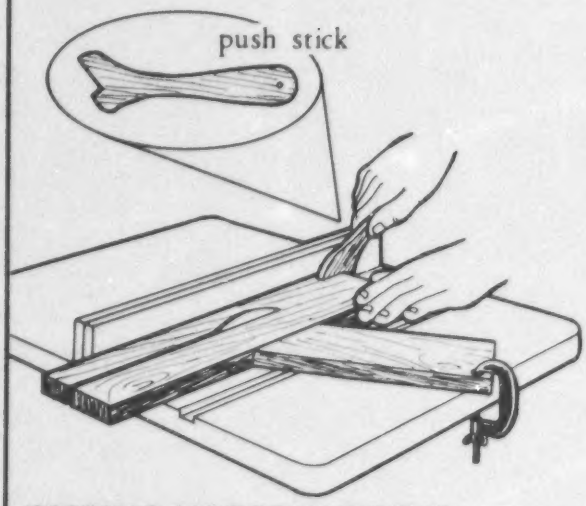
TILTING-ARBOR BENCH SAW



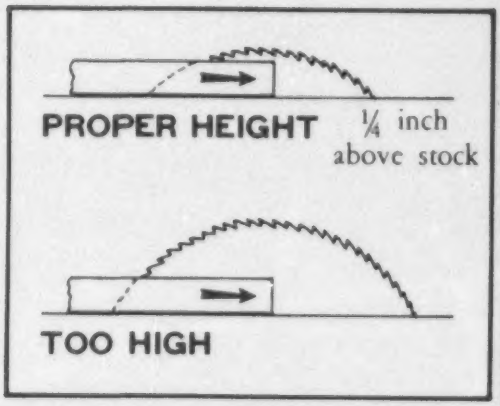
USING THE BENCH SAW

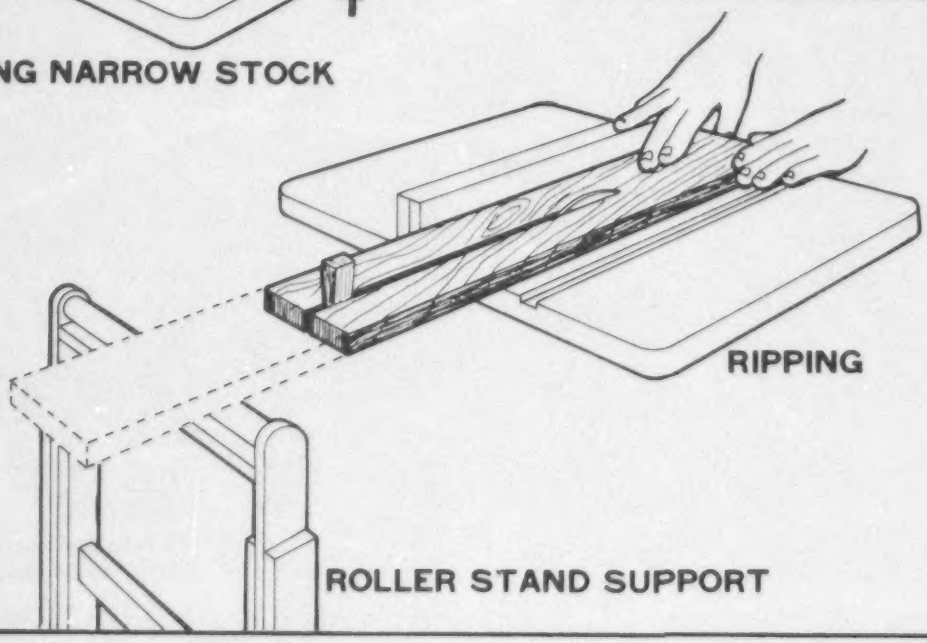


CROSSCUTTING

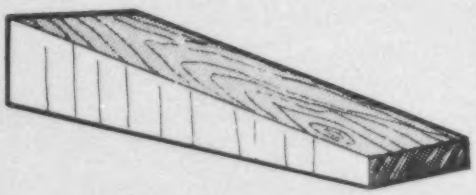


RIPPING NARROW STOCK

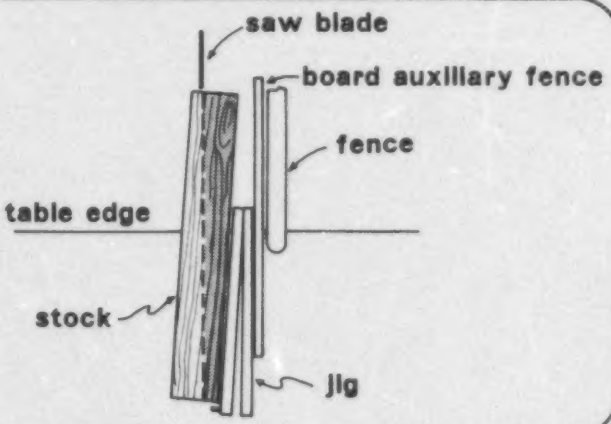


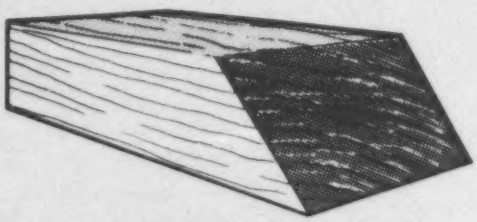


MAKING SPECIAL CUTS

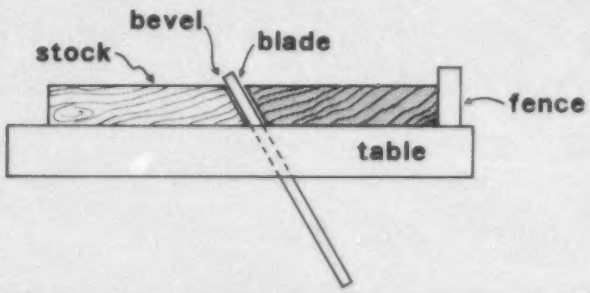


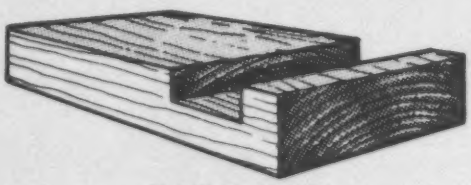
TAPER CUT



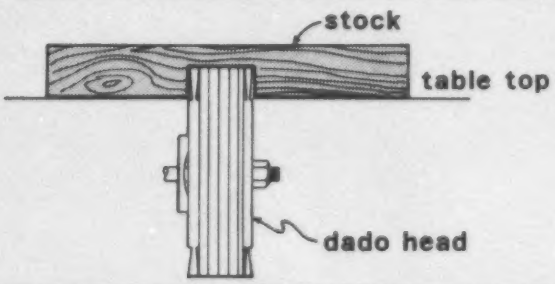


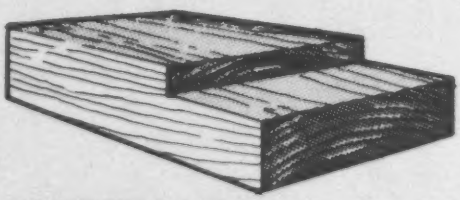
BEVEL CUT



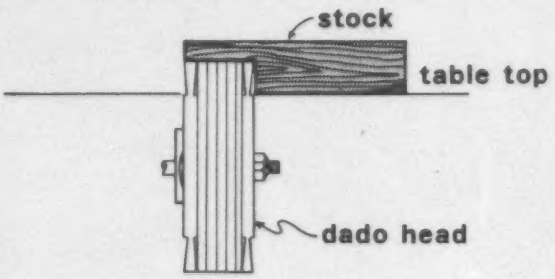


DADO CUT

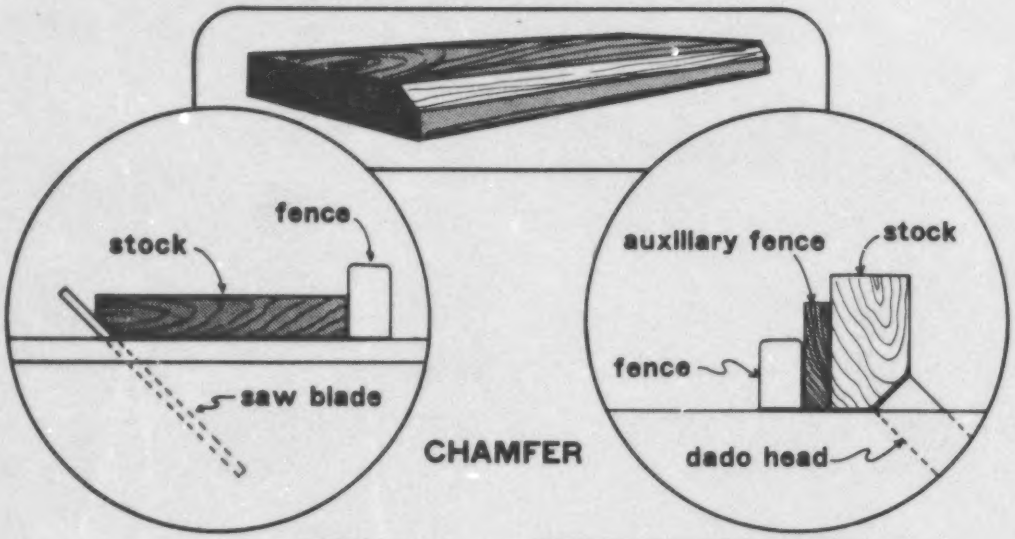




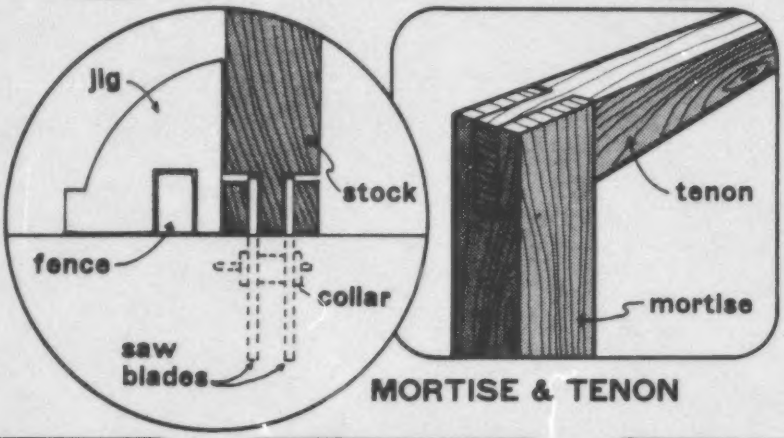
RABBET CUT (made with dado)



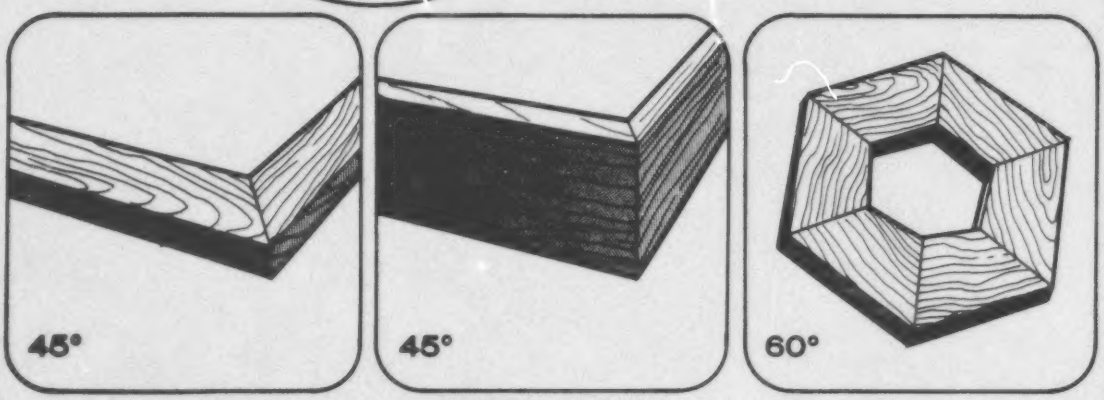
MAKING SPECIAL CUTS



CHAMFER

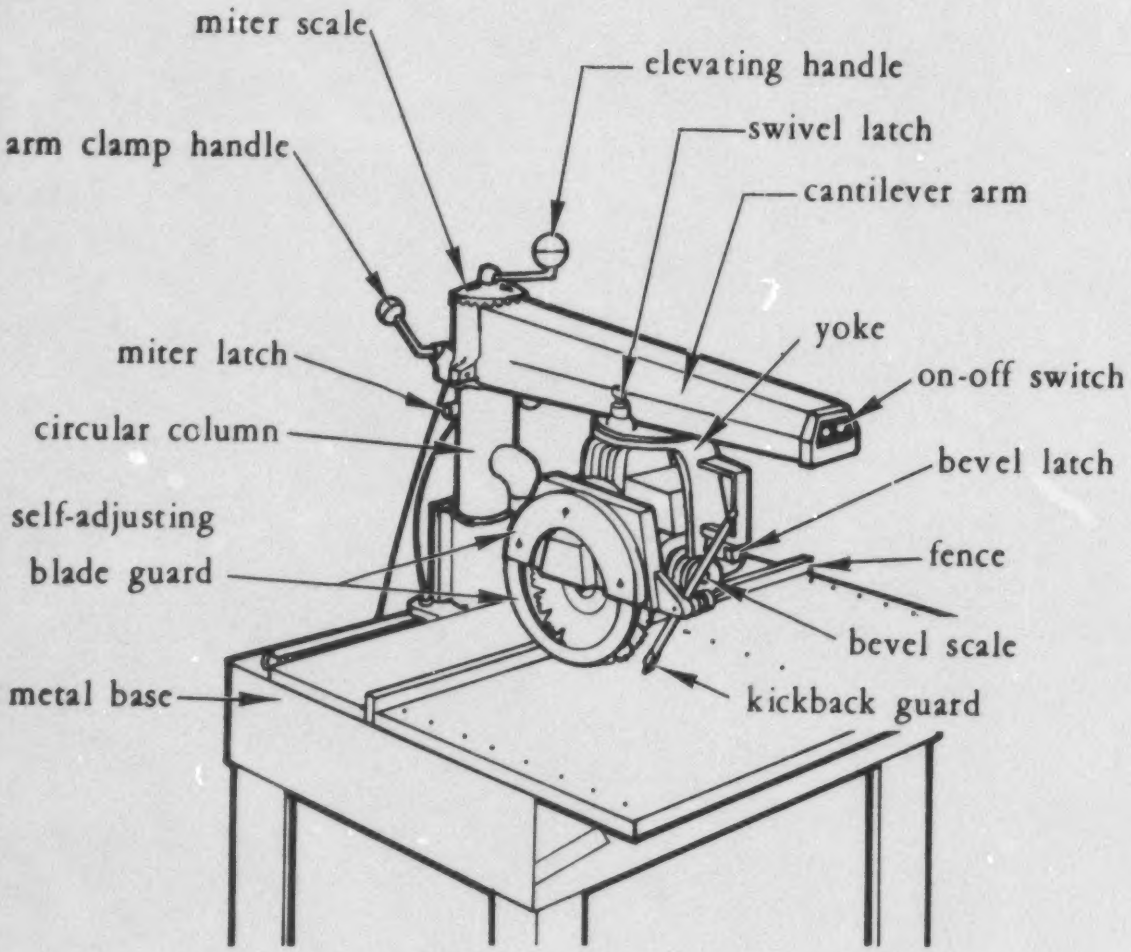


MORTISE & TENON

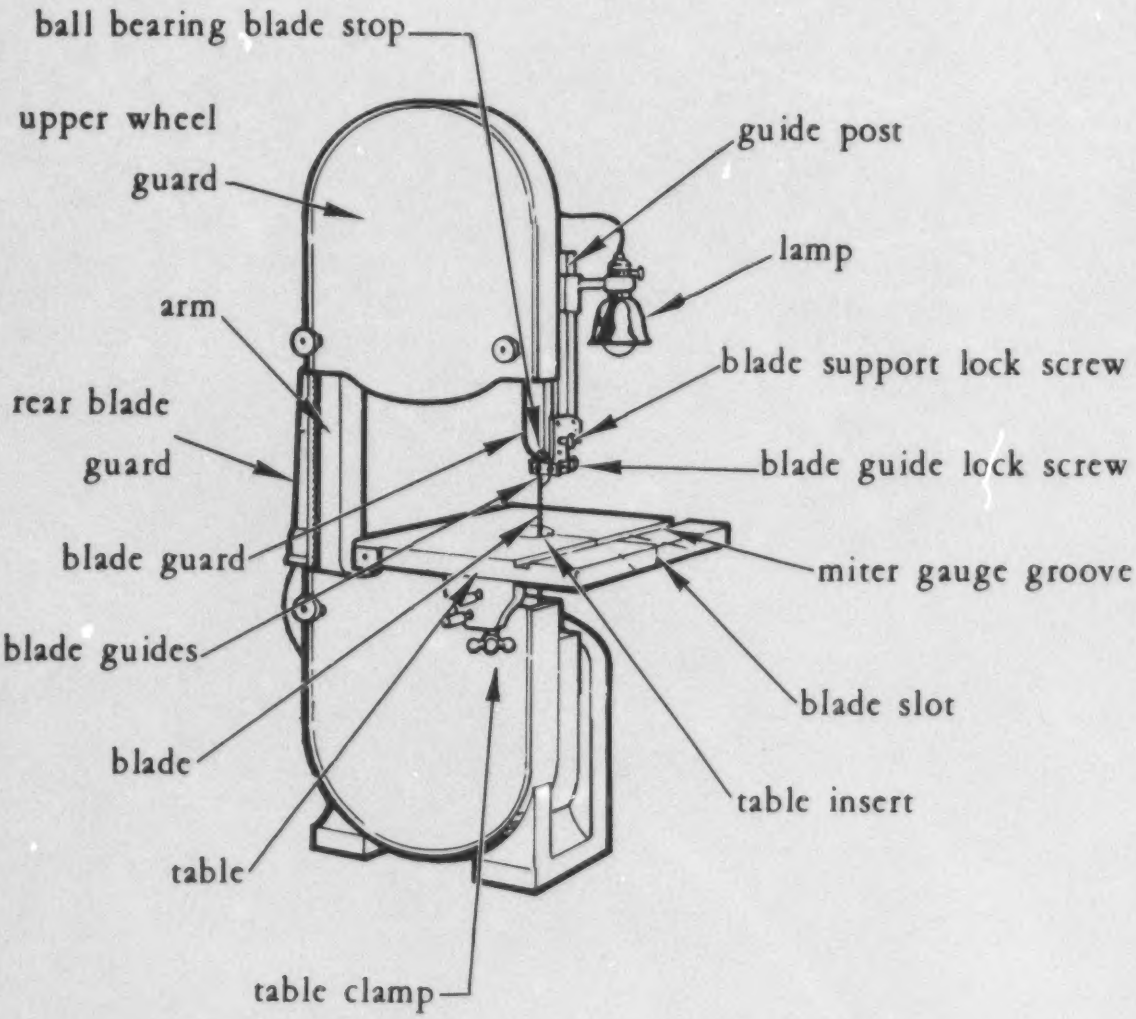


MITER JOINTS

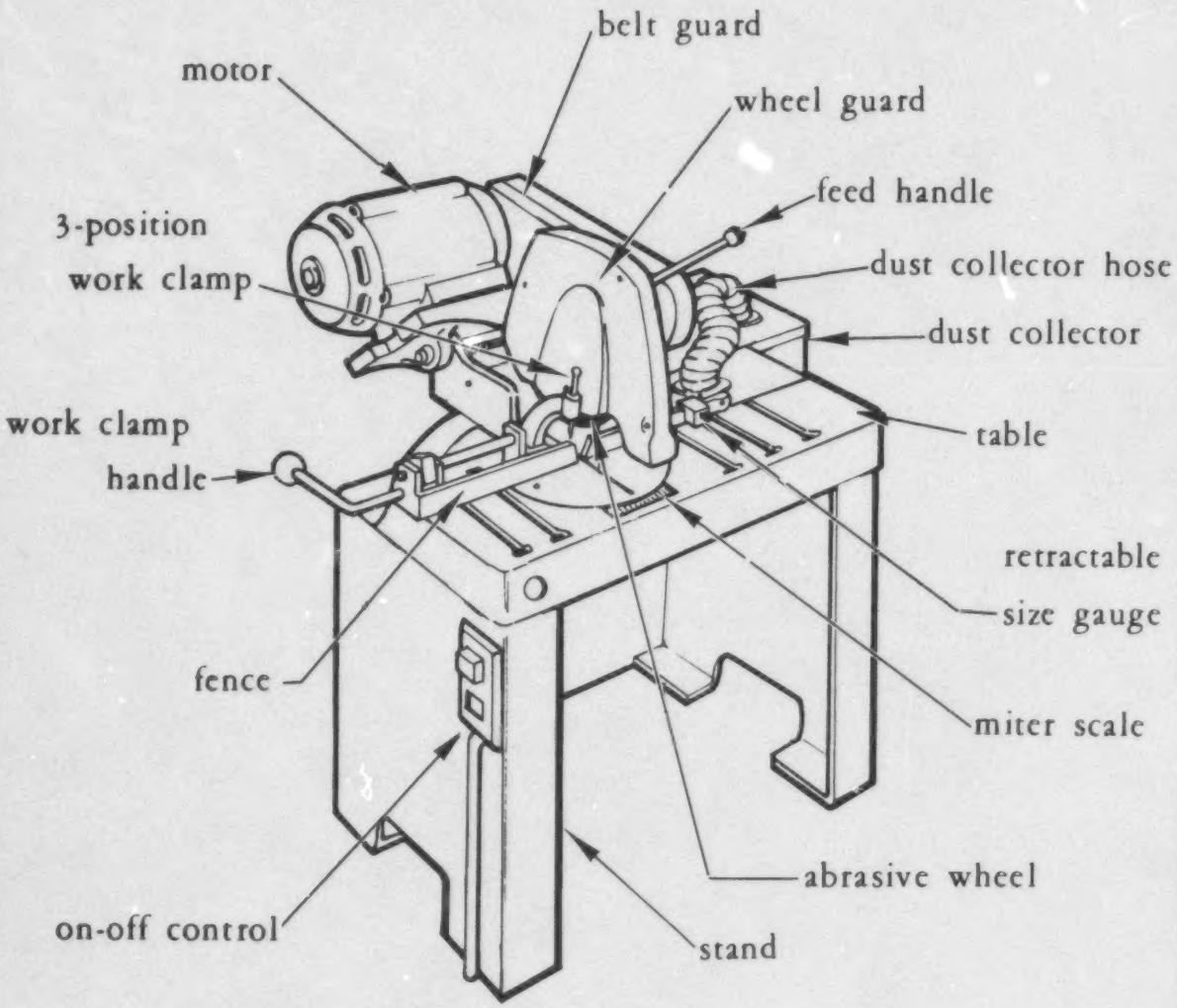
RADIAL ARM SAW



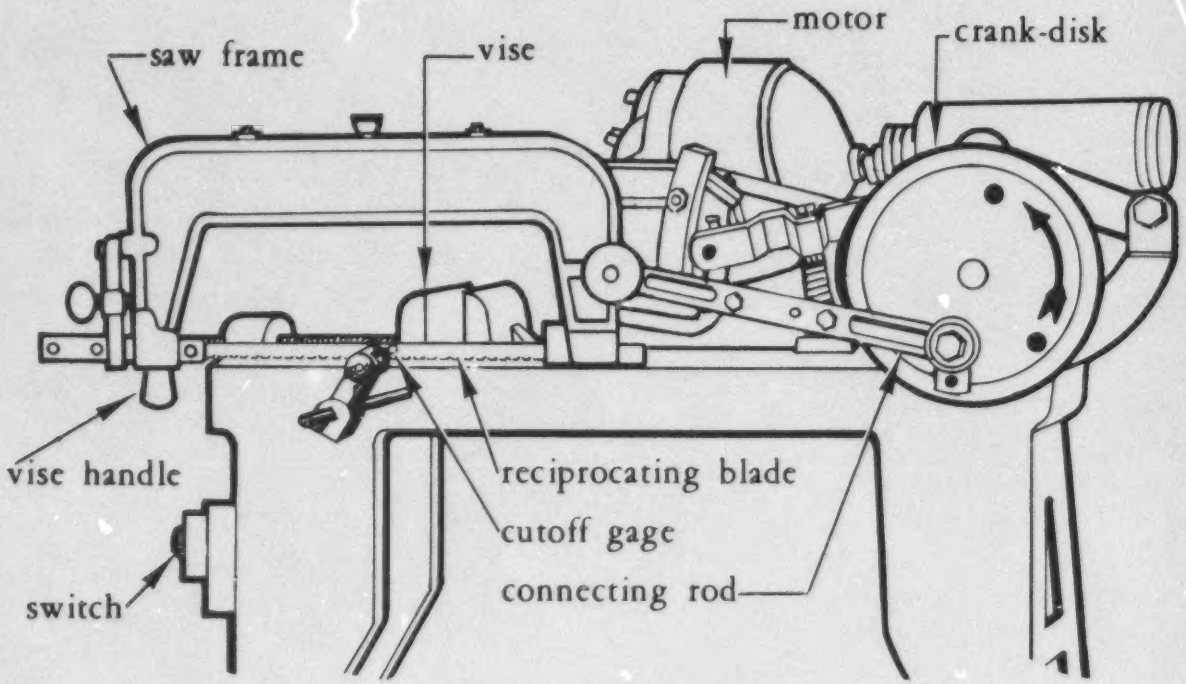
VERTICAL BAND SAW



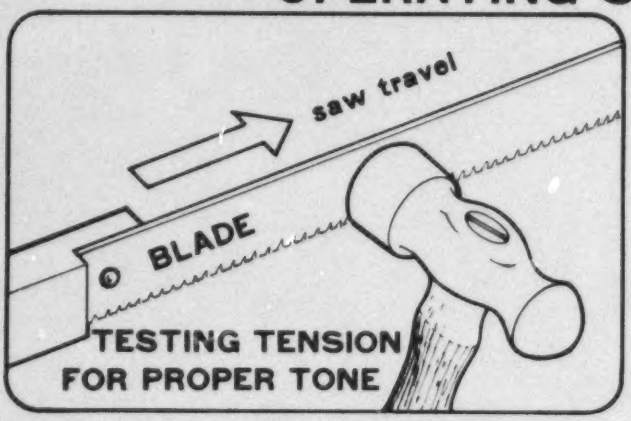
ABRASIVE CUT-OFF MACHINE

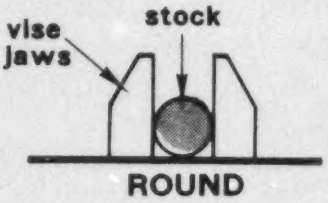


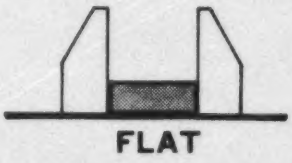
POWER HACKSAW

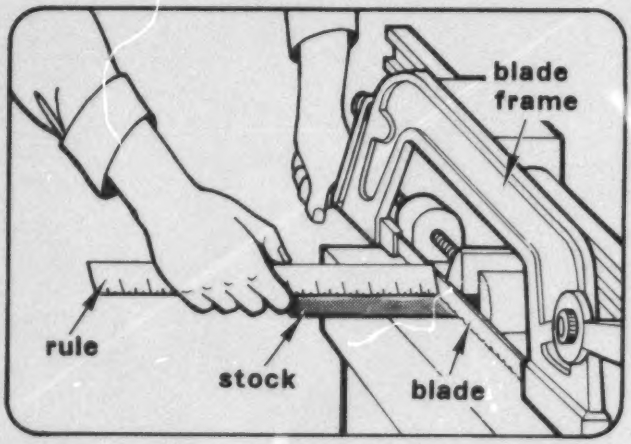


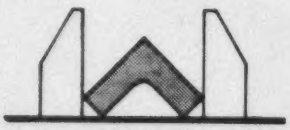
MOUNTING BLADES AND OPERATING SAWS

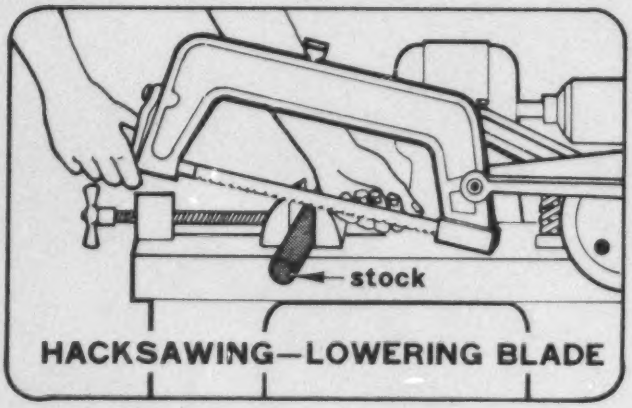




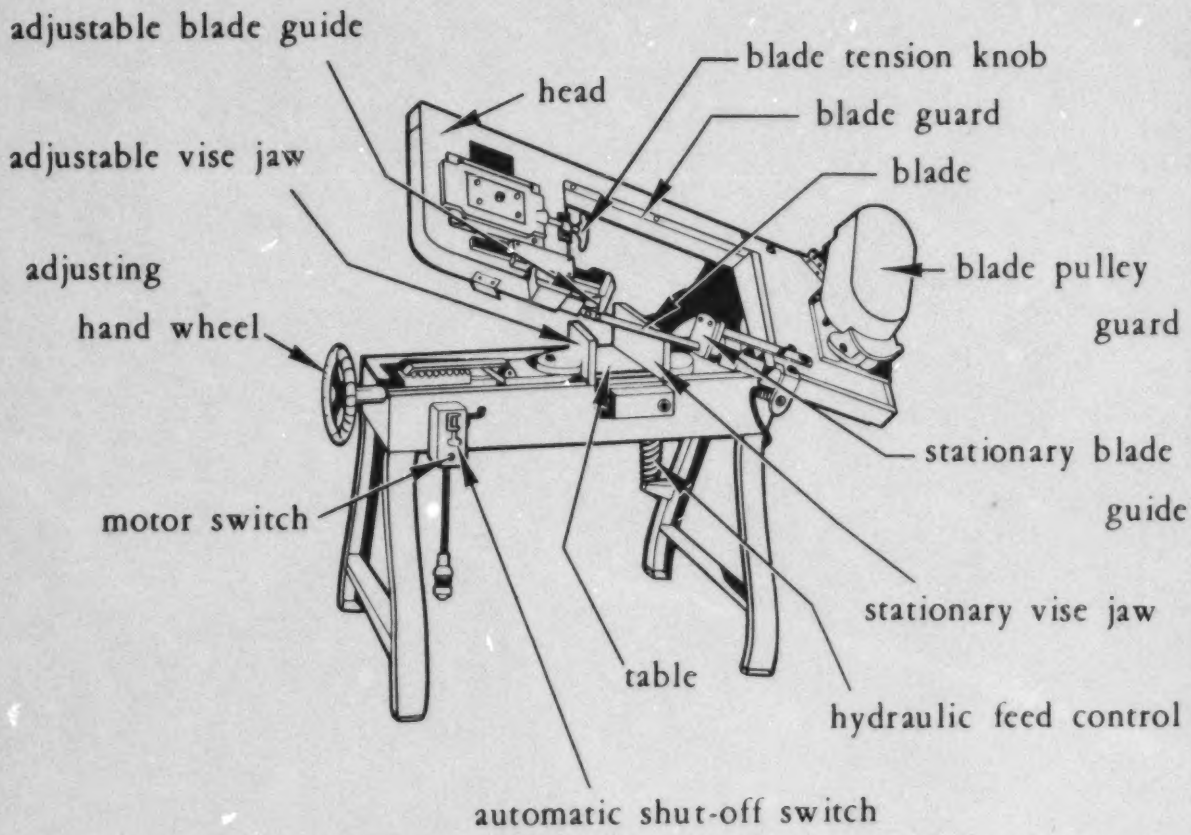




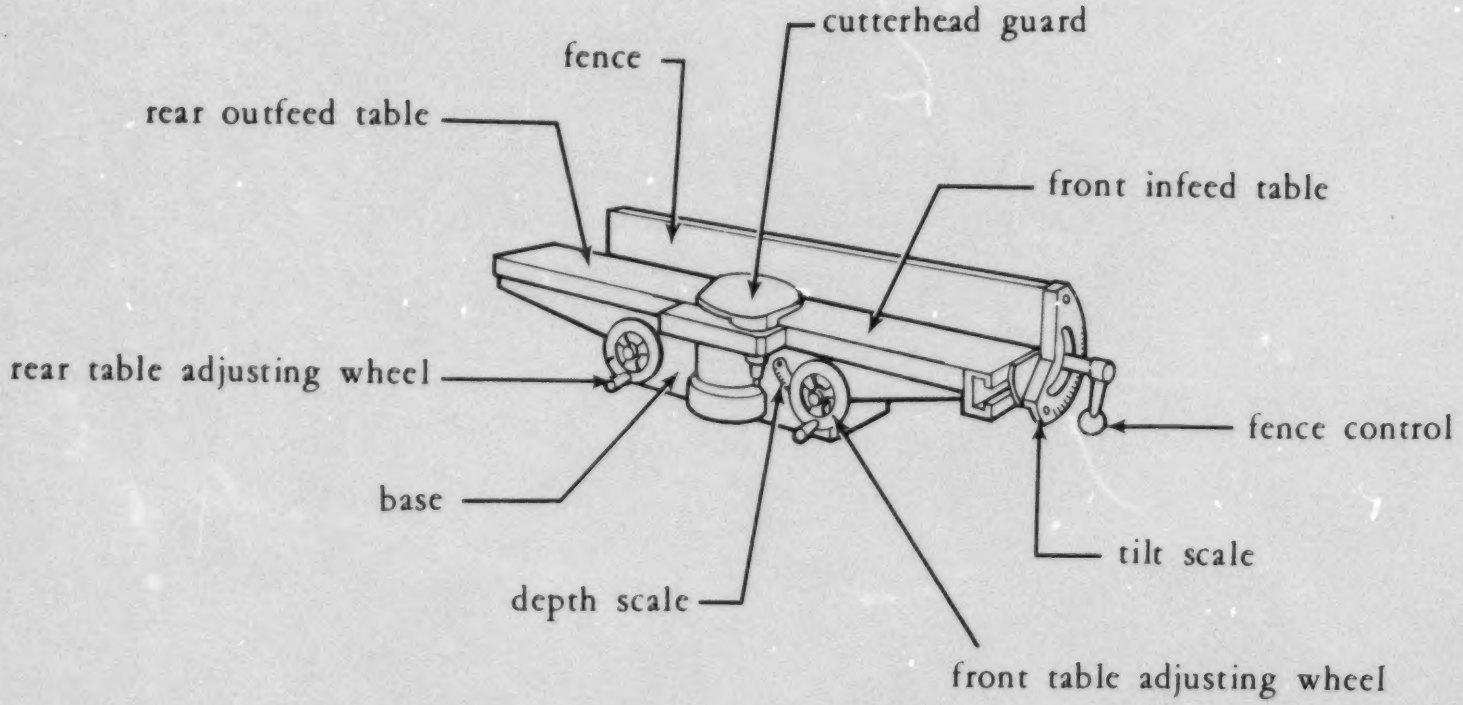




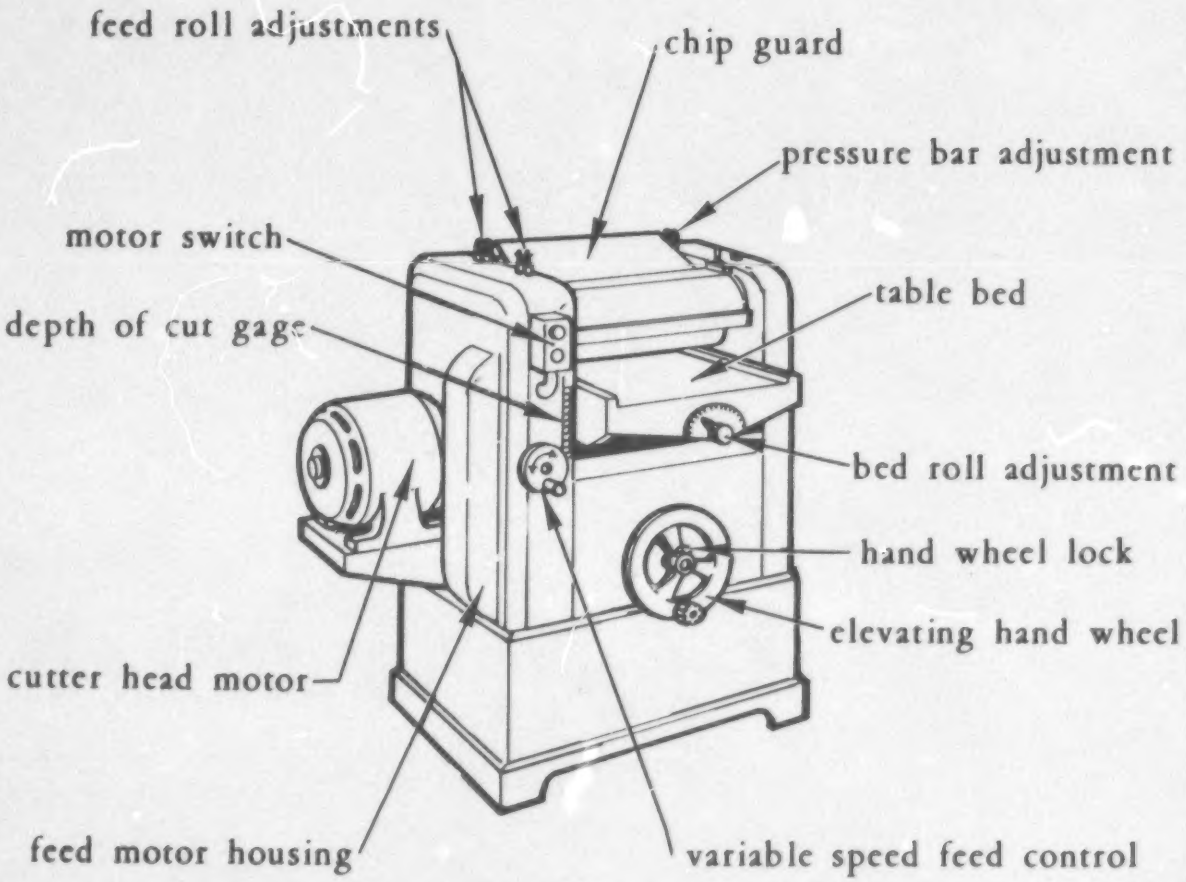
METAL CUTTING BAND SAW



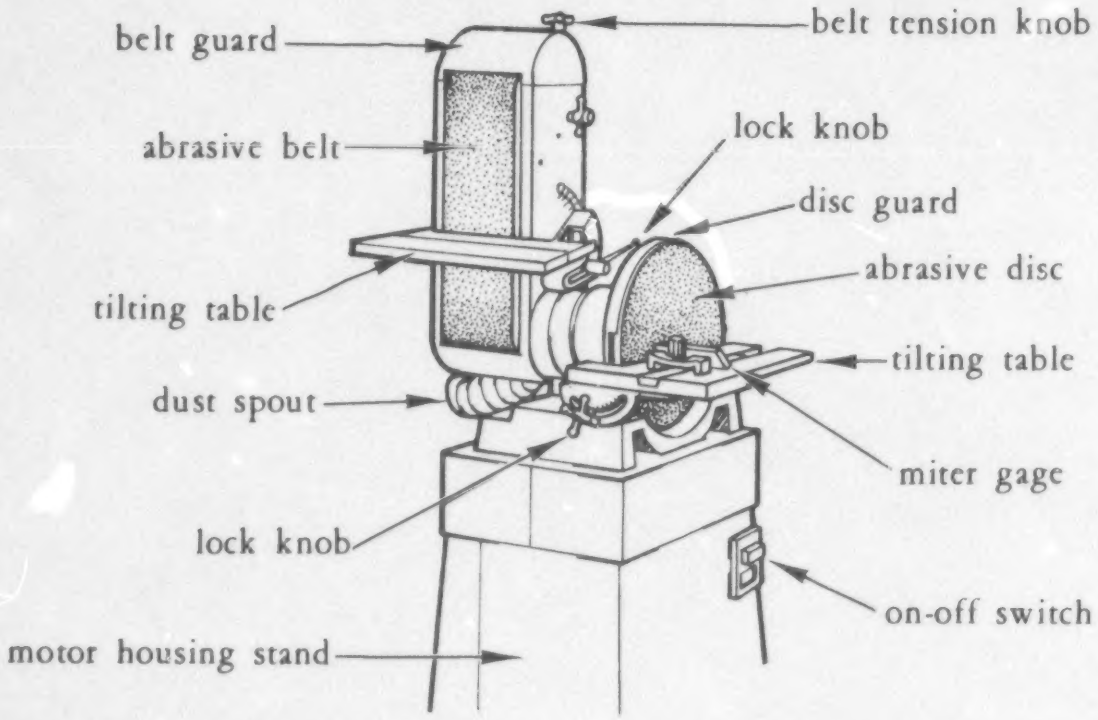
JOINTER


cutterhead guard
fence
rear outfeed table
front infeed table
rear table adjusting wheel
fence control
base
tilt scale
depth scale
front table adjusting wheel

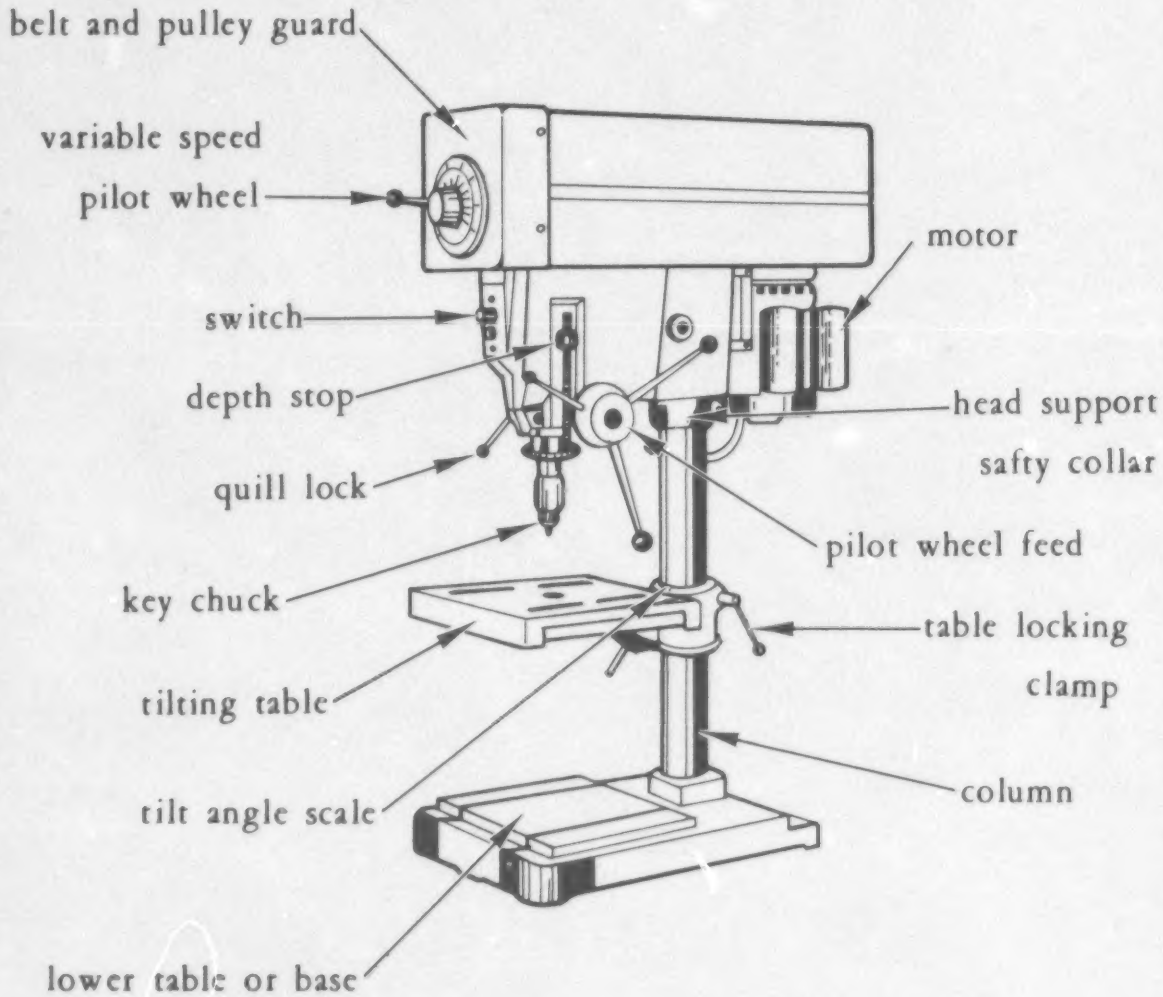
PLANER


feed roll adjustments
chip guard
pressure bar adjustment
motor switch
table bed
depth of cut gage
bed roll adjustment
hand wheel lock
elevating hand wheel
cutter head motor
feed motor housing
variable speed feed control

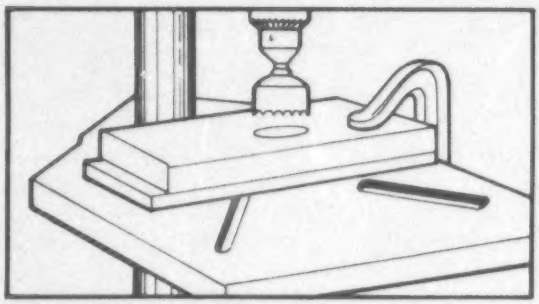
ABRASIVE
BELT-DISC SANDER



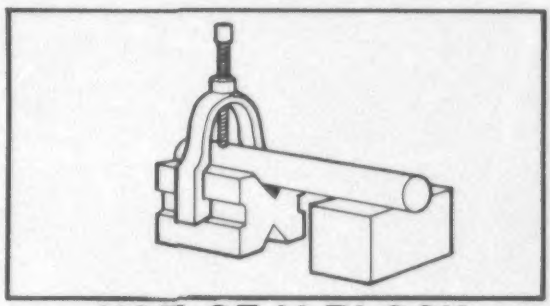
DRILL PRESS


belt and pulley guard
variable speed
pilot wheel
motor
switch
depth stop
head support
safty collar
quill lock
pilot wheel feed
key chuck
table locking
clamp
tilting table
column
tilt angle scale
lower table or base

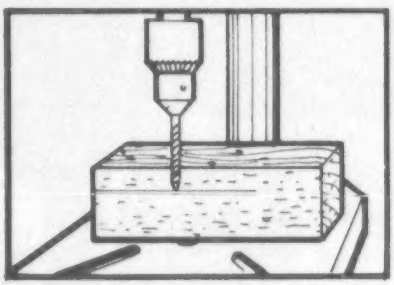
DRILLING WOOD AND METAL



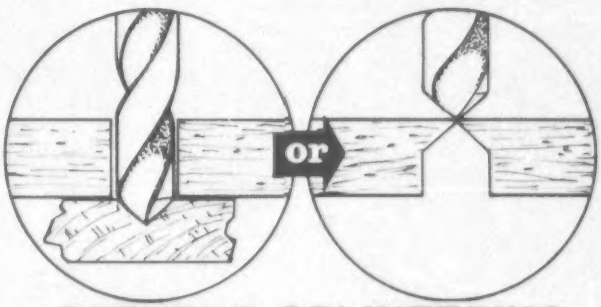
USE OF C-CLAMP



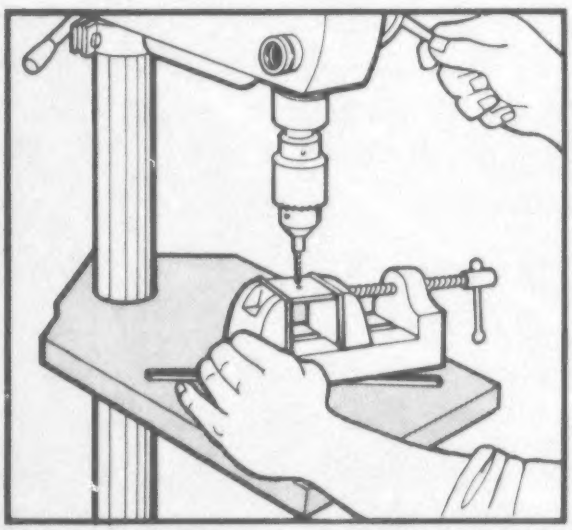
USE OF V-BLOCK
Y-CLAMP



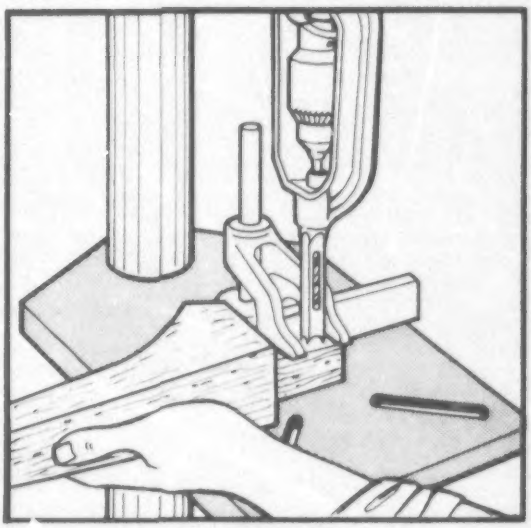
SETTING DRILL



PREVENT SPLINTERING

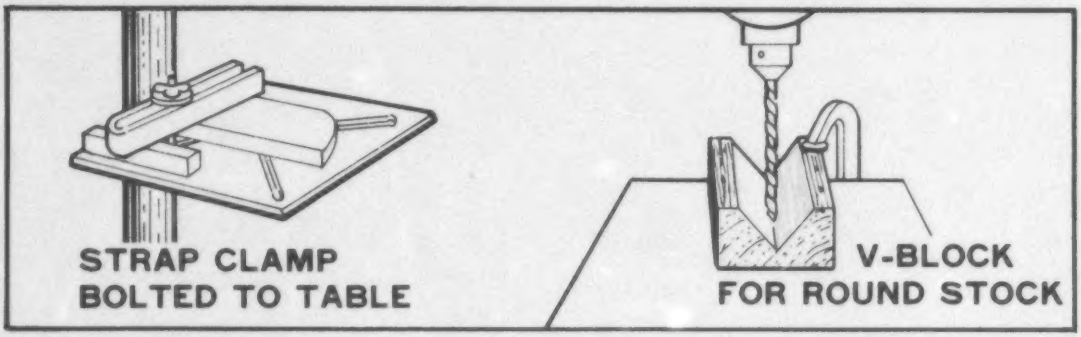


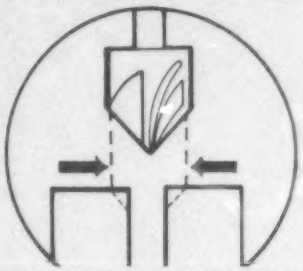
USE OF DRILL PRESS VISE

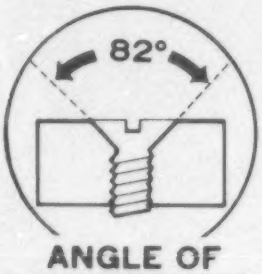


MORTISING

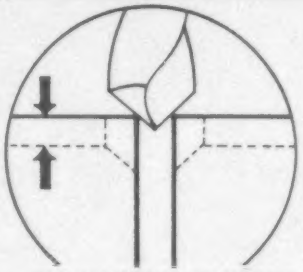
DRILLING WOOD AND METAL

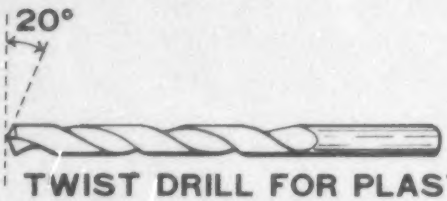



COUNTERSINK CUT

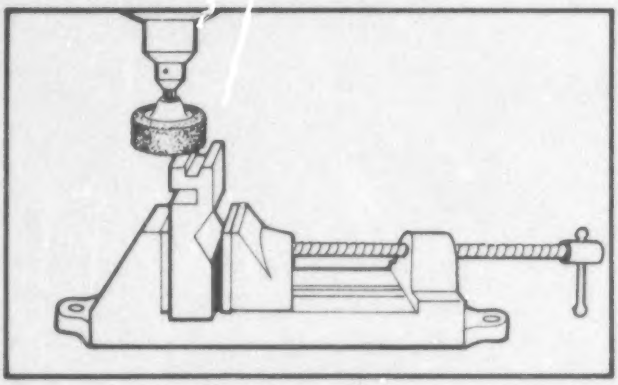


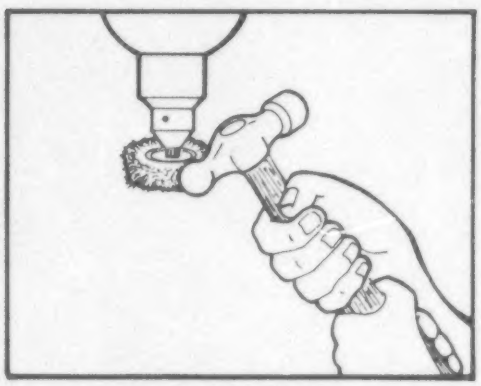
ANGLE OF COUNTERSINK


COUNTERBORE

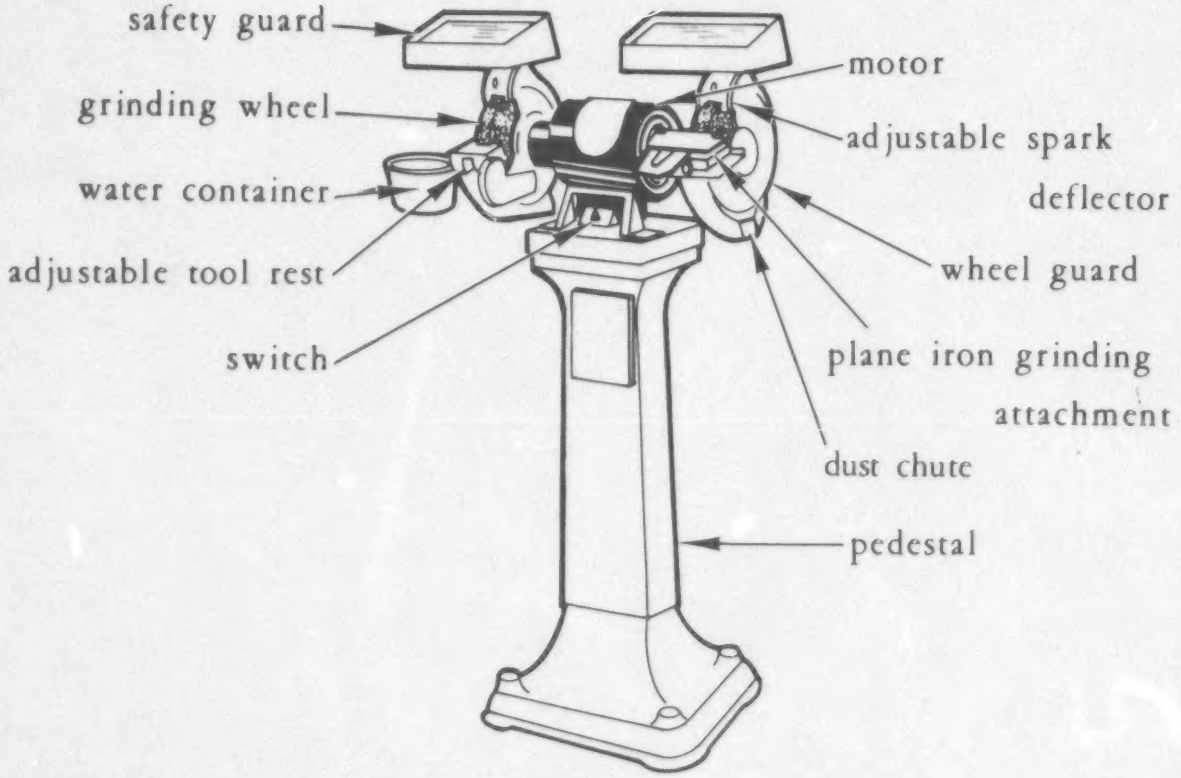


TWIST DRILL FOR PLASTIC

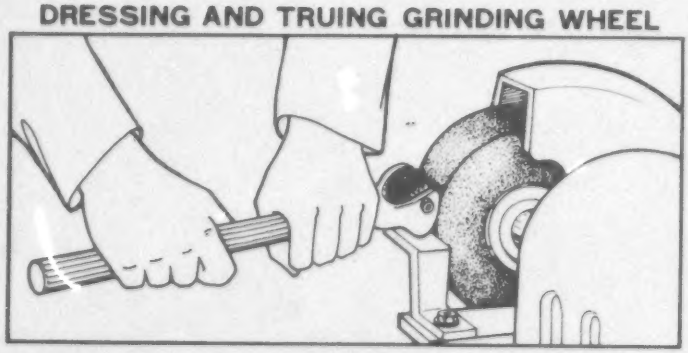

GRINDING


BRUSHING

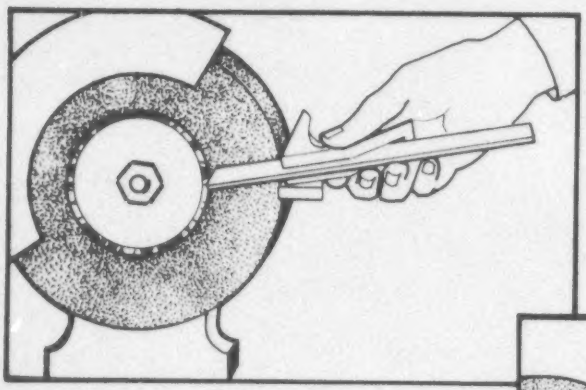
PARTS OF A GRINDER



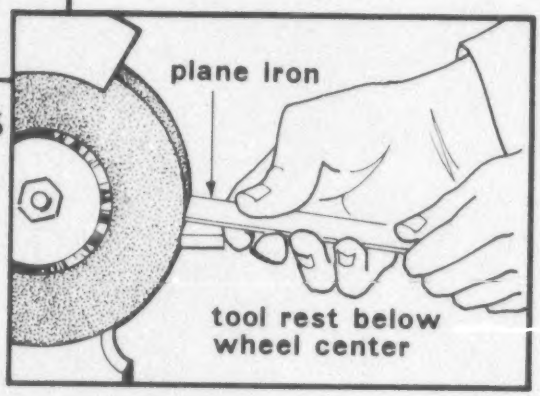
DRESSING AND TRUING GRINDING WHEEL

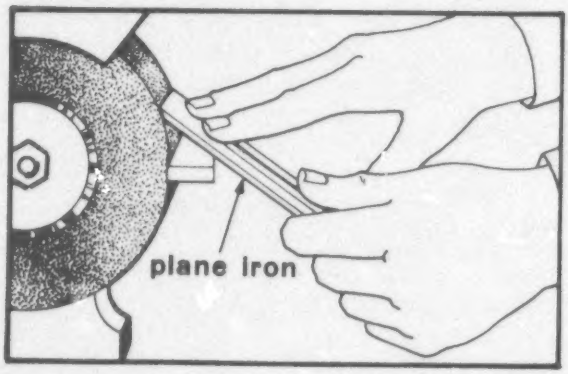


USING THE GRINDER

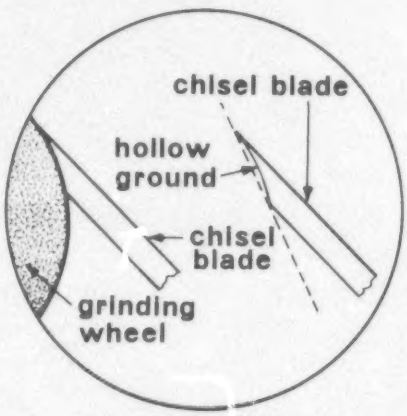


CHECKING SQUARENESS AFTER GRINDING



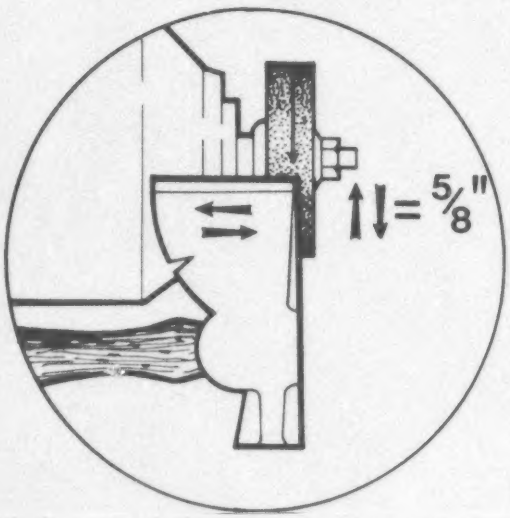


SQUARING A TOOL CUTTING EDGE

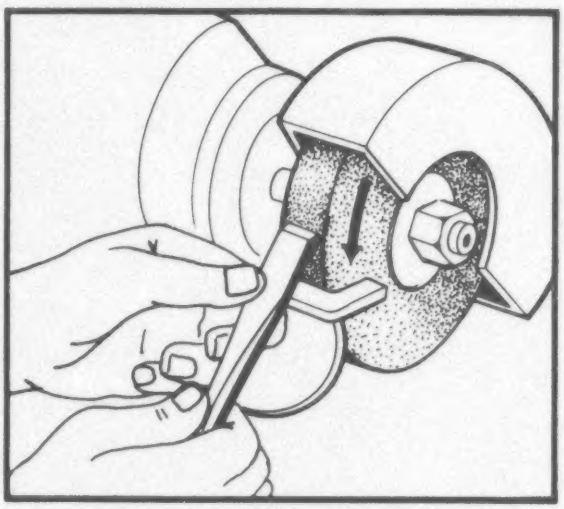


SHARPENING WOOD CHISEL

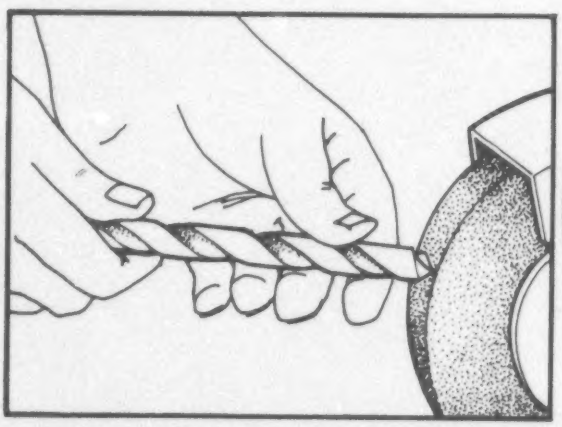
USING THE GRINDER



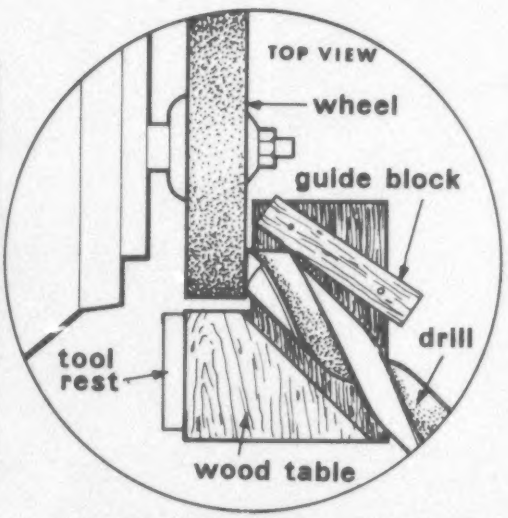
BACK AND FORTH—UP AND DOWN MOVEMENT



SHARPENING COLD CHISEL—70° ANGLE



UPWARD MOTION AS DRILL IS TURNED



WOOD TABLE CLAMPED TO TOOL REST

CONSTRUCTION AND MAINTENANCE

Unit A: Introduction

Topic 5: Identification and Use of Fasteners

Suggested Procedures and Activities: Exhibits of nails, screws, bolts, washers, nuts, and other fasteners may be used as teaching aids during the class discussion.

1. Importance of Fasteners

Machinery, equipment, and structures are subjected to heavy loads and severe stress; therefore, fasteners are important to their function and maintenance. Some of the purposes of fasteners are:

a. Simplification of manufacture - Many assemblies cannot be one piece; they must be made of two or more parts, held together by fasteners.

b. Simplification of repair - By removing fasteners an assembly can be separated into parts for inspection, repair, or replacement.

c. Safety - An assembly properly fastened will withstand load and stress with little possibility of coming apart.

d. Appearance - Screws and nails may be colored to blend with building materials. Nails may also be set, holes filled with putty, and painted over.

2. Nails

The nail is the most common method of joining pieces of wood together. Nails come in many sizes and types and are made from various metals. A specific nail is available for most every construction situation. The choice of the correct nail depends upon shape of head desired, corrosion resistance needed, and desired holding ability.

Transparency No. 1

a. Sizes of Nails

The term "penny", indicating nail size (length), came from one of the following sources of measurement in England.

(1) Six-penny and ten-penny nails could be purchased for either a six-pence or ten-pence per 100 nails.

(2) One thousand six-penny nails weighed approximately six pounds. One thousand ten-penny nails weighed approximately ten pounds.

(3) The letter "d" is used as a symbol for penny.

(4) Nails of the same penny size, regardless of type, are the same length.

Transparency No. 2

b. Types of Nails

(1) Common Nails - These nails are used more frequently than any other type of nail. They are made of wire, have flat heads, and range in size from 2d to 60d. The larger common nails are known as spikes. They are used for rough work where holding power is important. They are used mainly on rough work such as framing, fencing, and form building.

(2) Box Nails - Box nails range in size from 2d to 40d. They have less tendency to split the lumber than does the common nail due to their being smaller in diameter. The box nail is used for building crates, boxes, and the nailing of siding. They are also made of wire and have flat heads.

(3) Finishing Nails -These nails are used for finish work. The heads are small and barrel shaped so they can be sunk below the surface and the holes filled with a wood filler or putty. The sizes range from 2d to 20d. These nails are used on cabinet trimmings and cupboards.

(4) Roofing Nails - Roofing nails have a very large flat head. The shanks are of different sizes and types. The most common shank is barbed. The nails are used to install rolled or shingle asphalt roofing. They range in size from about 3/4 to 2 inch. These nails are galvanized.

(5) Flooring Nails - As the name indicates, these nails are used mainly for nailing flooring; but they are used on other heavy materials. The nail diameter and head are slightly larger than the finish nail; however, the head can be countersunk. The flooring nail ranges in size from about 7d to 10d.

(6) PLasterboard or Gypsum Board Nails - These nails are small with a flat head. They range in size from 1 to 1½ inches in length. They are used to join plasterboard to a wood base. These nails are also used to apply rock lath (a base for plastering).

(7) Casing Nails - These nails can be used for flooring, but they have a smaller head and smaller shank in diameter than does the flooring nail. The head can be countersunk. These nails range in size from 4d to 40d and are used mainly for outside finish work. They are thicker than a finish nail.

(8) Shingle Nails - Nails of this type are small (3d to 6d) with flat heads. The galvanized box nail is used for wood shingles.

(9) Hinge Nails - There is one other type of nail that is being used for lattice work and roofing because of its holding power; and that is the hinge nail. They have oval or countersunk flat heads and range in size from 4d to 20d.

(10) Other Types of Nails - Other types of nails are: masonry, duplex-headed, ratchet, T, copper clout, lead-capped metal roofing, screw and plain shank roofing, and escutcheon pin.

Transparency No. 3

c. Driving a Nail

(1) After the proper nail has been selected, hold it firmly with the thumb and fingers of one hand, then strike a light blow with the hammer to set the nail for driving.

(2) If more than one nail is used they should be set in a zig-zag line to prevent splitting the wood.

(3) If nails are driven in hardwood, drilling a hole slightly smaller than the nail will prevent the wood from splitting.

(4) Nails driven diagonally will have a better holding effect than nails driven straight into the lumber. Toe-nailing is another way of driving nails at an angle.

(5) The last blow of the hammer should be judged properly in order not to leave a hammer face mark on the board.

(6) Finish, casing, and flooring nails may be set by using a nail set slightly smaller than the head of the nail.

(7) Nails should be clinched across the grain of the wood. Hitting the point of the nail after it has been clinched flat on the surface will make the nailed material safer to handle.

Transparency No. 4

3. Miscellaneous Fasteners

a. Corrugated fasteners

Corrugated fasteners are used to join boards together such as corners and butt joints in windows and doors and corners for picture frames.

The thickness of the corrugated fastener should be at least 1/8 inch less than the thickness of the board where it is used. The fasteners range in size from 1 to about 6 inches in width and from ¼ to 1 inch in depth. Regardless of the width of the fastener, it should be driven evenly into the material. Hammer blows should be placed so that it enters the board straight and parallel.

b. Staples

(1) Staples range in sizes from 3/8 inch to 2 inches. Wide crown staples have a 1 inch crown. They are used with a staple gun. Staples are used for millwork, asphalt shingles, butt joining, and ceiling materials.

(2) Wire staples are made in different sizes. The staple used to construct barbed wire and heavy net wire fences may be about 1 inch long, while the small mesh wire staple may be less than 3/4 inch in length. Fencing staples vary in length from 3/4 inch to 2 inches.

Drive staples with the points out of line or crosswise with the grain. This method prevents both prongs entering the same grain. Also drive the staple at an angle so that the upper prong is deeper in the post than the lower prong. Staples should be snug against the wire and should hold the wire snug against the post. The staple and wire should not be buried in the post.

c. Bolts

(1) The difference between bolts and screws can be explained as follows:

(a) A bolt is usually thought of as a device used with a nut to fasten two parts together. A screw is usually thought of as a device for fastening two pieces together by passing through a hole in one and screwing into a tapped hole in the other, without the use of a nut. Bolts are usually sold with the nuts accompanying them, while screws are not provided with nuts.

(b) The head (and nut) of a bolt is generally square or hexagon and is tightened by means of a wrench. The head of a screw is usually round in shape and is provided with a slot or some other means of tightening with a blade such as a screwdriver. (Exception: Hex-head cap screw.)

(c) The sizes of bolts are usually given in fractional inch sizes, such as ½", 5/8", etc., while the sizes of screws may be in fractional inch sizes but are usually expressed in numbers from 0 to 30, to denote the gauge size of the steel wire from which the screws are made.

(2) Selecting and Using Bolts

(a) Bolts must have the same qualities as found in other materials. That is, they must be made of good metal, be long lasting, strong, corrosion resistant, reusable, temperature resistant, capable of withstanding vibration, and in most instances easy to remove. Bolts are classified according to grades by the Society of Automotive Engineers (SAE). The grades are determined by the material in a bolt and the treatments of the tensile strength (TS) (pull withstood by a bolt without breaking or being distorted). SAE markings (slashes) on the head of a bolt identify grade markings and strength.

(b) There are several different types of bolt heads found in each class of bolts. Each type of head is especially made for a certain function. For example, a hexagon or square head bolt is used where the parts of a machine may be disassembled frequently. The round head carriage bolt is used mainly to attach metal to wood. The shoulder of the carriage bolt is pulled into the wood, and this prevents it from turning. A flat head carriage bolt is used in the same manner as the round head bolt, except that the head is flush with the surface. The large flat or tapered head carriage bolt (elevator bolt) is used in the same manner as the standard flathead bolt, but the head covers a larger surface. There are three different types of plow bolt heads. Each bolt is made for a specific purpose. All plow bolt heads are made to countersink into the metal, causing the head to be flush with the surface. These types of bolts are used to attach cutting blades on earth moving equipment and to attach plow shares to the moldboard. Hex socket head bolts are found on machinery where it is necessary to recess the head, and twelve-point head bolts are used where small heads are needed.

(c) The size of a bolt is determined by the length and diameter of the body. Major diameter instead of minor diameter is used. The threads on a bolt are measured by the number of threads per inch, and major diameter is the measurement from the top of the threads (crest) on one side to the top of the threads on the other. Bolts may be described by using following symbols:

$$\tfrac{1}{2} - 28 \text{ UNF} - 2A \times 3\tfrac{1}{2}$$

$\frac{1}{2}$ refers to $\frac{1}{2}$ inch bolt (diameter)
28 refers to 28 threads per inch
UNF refers to unified thread standard (fine)
24 refers to fit symbol
$3\frac{1}{2}$ refers to $3\frac{1}{2}$ inches in length

Transparency No. 6

(d) Detailed description of the most commonly used bolts

Machine bolts may be used for heavy construction such as livestock feeders, gates, and trusses for buildings. The heads of machine bolts can be held with a wrench while being tightened. The size range is similar to a carriage bolt, about ½ to 1-1½ inches in diameter, and the length is from 1 to 30 inches. They have either a square or hexagonal head and Unified National Coarse threads (UNC), UNF threads (Unified National Fine) or Unified National Extra Fine (UNEF).

Carriage Bolts are generally considered the woodwork and wood-metal work type bolt due to the square shank under the round oval head. The square shank prevents the bolt from turning once it is set in the wood. The head cannot be held by a wrench; therefore, it may be difficult to remove; especially if the bolt is covered with rust. The length may range from about 1 inch to 20 inches. These bolts are threaded like machine bolts. These bolts are usually used on farm structures where metal is attached to wood.

Stove bolts are used for lighter work than are carriage bolts. They have round, oval, and flat slotted heads and may be loosened or tightened with a screwdriver. The stove bolt may be purchased with a Phillips head and in many sizes. The threads extend the full length of the bolt. The length of stove bolts ranges from 3/8 inch to 6 inches. These bolts are made with UNC threads.

Lag bolts are used with expansion shields to fasten wood and other materials to concrete, bricks, and stone. When a lag screw or bolt is inserted into the metal shield the shield expands in the hole as the square head of the bolt is turned clockwise with a wrench. This bolt does not have a nut. When attaching metal to wood or wood to wood it is necessary to drill two sizes of holes - one for the threaded part and one for the non-threaded part.

Stud bolts are used to fasten the cylinder head of an engine to the cylinder block. They are made so that one end can be attached by inserting in a prepared bolt hole, while the other end is free to accept a nut to draw the two pieces of metal together.

(e) The use of bolts in joining metal together or joining metal with other materials is as follows:

(1) Center punch the top piece of metal at the point where the metal is marked (+) with a scratch awl.

(2) Select the proper size of twist drill to make a hole for the bolt. If the hole is too small, a long-tapered reamer may be used to enlarge it.

(3) Use the following methods to drill holes in pieces of metal that are to be joined together:

(a) Clamp one or more pieces of metal together and drill all aligned bolt holes at the same time.
(b) Mark the two pieces of metal separately and drill the holes separately; then place a bolt in the two drilled holes to hold the metal in a firm position for drilling the remaining holes.

(4) Draw the nut/s tightly when bolting metal together. Proper pressure on a nut will not damage the threads or stretch the bolt, but excessive twisting pressure will lengthen a bolt, deform the nut, and possibly cause the bolt to twist or turn in the hole. On the other hand, if the bolt is not properly tightened, it may work loose and may be sheared or cut by metal movement. These are some of the reasons why torque wrences are used to tighten bolts on most machinery and why slotted and castle nuts are used with cotter pins.

(5) Secure bolts on vibrating machinery with lockwashers fitted under the nut. When metal is attached to wood, flat washers may be used between the bolt head or nut and the wood surface. A wing nut is used where tightening pressure can be accomplished by the thumb and finger. Lock washers are usually not used with wing nuts.

(6) Use the proper size and type of wrench on bolt heads and nuts. For example, open end wrenches are used on either the square head or hexagon head bolts and nuts. Adjustable wrenches are also considered good square nut wrenches. A socket or box end wrench is thought of as a hexagon bolt wrench. Pipe wrenches and pliers are not made to use on square or hexagon bolts or nuts. Pipe wrenches can be used on pipe or round rods.

(7) Steps to consider when using a torque wrench to tighten bolts are as follows:

(a) Make smooth steady pulls to prevent over-torqueing.
(b) Before torqueing bolts, clean dirty holes, bolts, and nuts.
(c) Damaged or blocked threads may give a false reading on the torque wrench.
(d) Extra torque may be used to pass over these areas.
(e) When tightening a bolt and a popping sound occurs, loosen

the bolt or nut and retighten. Make a steady pull or turn with the wrench and at the same time take the torque reading.

(f) Lubricate bolts and nuts or bolt holes very sparingly. A hydraulic lock may occur if a bolt hole contains too much oil.

(g) Use torque tables when necessary. The table will give the outside diameter or body size and foot-pounds and inch-pounds tightening values of lubricated bolts and nuts.

Transparencies Nos. 7 and 8

d. Screws

(1) Selecting and Using Metal Screws

(a) The two major types of metal screws are sheet-metal (self-tapping) and machine screws. Self-tapping screws are used on such materials as sheet metal, plywood, plastic, asbestos, and many other materials. These screws are an important type fastener used in agriculture machinery, farm metal buildings, heating and cooling installations, construction of ducts, and repair jobs where thin or sheet metal is involved. The use of these screws eliminates or reduces welding, riveting, and soldering.

(b) Machine screws are used mainly in the construction of equipment and machinery. They are also used in building construction. For example, butt hinges and door closers are attached to metal jambs with machine screws. Certain types of lock cases are assembled with machine screws. The purpose of this type of screw is to assemble metal parts. They are used without nuts; therefore, the first part of metal has a bored hole for the screw, and the second part has a tapped hole that receives the threads.

Types of sheet metal screws are determined by the following characteristics:

The different types of common screw heads.

Flat	Binding
Oval	Pan
Round	Blunt

The heads may be reed-prince, slotted, Phillips, frearson, clutch, or one-way.

(c) The gage numbers of sheet metal screws range from 0 to 24 and the length from ¼ to 5 inch. However, the common length is up to 2 inches and the gage to 14. The following examples are

used when identifying metal screws: a 1-1¼ inch number 10, flathead steel screw is written 1-1¼" No. 10 F. H. S., and the same screw in brass, but round head, is written 1-1¼" No. 10 R. H. B.

(d) Screws are made of steel, brass, bronze, and copper metals. Steel screws are used for ordinary work, and they are usually cheaper than alloy and copper screws. Brass and alloy-type screws are best suited for construction purposes where the screw is subjected to moisture. Copper screws are used with copper metals, giving the finished product an ornamental appearance. Screws are finished in many colors. They are: bright metal, blue, brass, bronze, and copper. They are also painted in various colors.

(2) Machine screws are identified by the following characteristics:

(a) The types of screw heads

Flat	Round	Hex
Oval	Filister	

The head slots and shapes include slotted, fluted, Allen, clutch Phillips, and hex.

(b) The gages of metal screws range from .060 (0) to 3/8 inch in diameter. This is the same gage measurement used for woodscrews except woodscrews exceed the 3/8 inch. The length may range from 1/8 to 3 inches. The screw gage number and length are used to make the selection. They are made with either UNC (Unified National Coarse) or UNF threads. The description may be written for a 1 inch long and ¼ diameter screw with a flat head and fine thread as follows:

¼" - 28 x 1" - F. H. S. The number 28 in this description is threads per inch. These screws are found in steel or brass.

(3) The procedure for installing self-tapping screws is:

(a) Mark the hole location and prick punch tap lightly with a center punch.

(b) Either punch or drill the hole. Make the hole just slightly larger than the root diameter excluding the threads. Hold the drill behind the screw to sight and compare screw diameter with the drill diameter. The surest method of determining or selecting the proper screw size is to use standard handbooks that give minor diameters of screws and hole sizes.

(c) Use a punch to align the holes. If the two pieces of material are loose, clamp them together before inserting the screw with a screwdriver.

As the screw is driven into an untapped hole it cuts its own thread. Self-tapping screws can be found with pointed and blunt ends.

(d) If two pieces of metal are to be fastened together by using machine screws, drill the clearance hole slightly larger than the upper part or shank of the screw. A cap screw (a type of machine screw) is used where threads are required only in the second piece of metal. Locate and drill a second hole the right size. Tap this hole with the proper threads, and use a wrench or screwdriver, whichever is appropriate, on the screw head to draw the two pieces of metal together. This type of machine screw is made for heavier type fastening than is the ordinary screw.

(4) Wood screws are identified in the following manner:

(a) Flat head
(b) Round head
(c) Oval head
(d) Drive screw
(e) Drywall phillips
(f) Self-driving phillips
(g) Fillister head
(h) Square head leg screw

e. Rivets

(1) Rivets resemble certain types of bolts except that they have no threads. They are used to fasten two or more pieces of metal together. Rivets are used when it is not feasible to fasten metals by other methods. For example, if heat reduces the strength of a metal, rivets are used as fasteners. Light metal such as aluminum sheet metal is usually riveted. This type of fastener is found in sizes from ¼ to 3 inches long and from 1/8 to 3/8 inch in diameter. There are at least six different types of rivet heads. The most common types have round and flat heads. Rivets are selected by specifying the following: length, kind of head, diameter, and type of materials. The diameter of the rivet should be about 1/64 smaller than the diameter about 1-1½ times the thickness of the rivet diameter.

(2) The common types of rivet heads and rivet body structure are:

Round, flat, countersunk, truss, cone, and steeple head shapes. Tubular, split, solid, and blind are types of body structures.

(3) The steps that may be used in riveting metal include:

(a) Mark (+) the center of rivet holes on the metal with an awl, and center punch the hole location.

(b) Use a twist drill the size of the rivet to make the hole.

(c) Countersink the hole if countersunk rivets are to be used.

(d) If the rivet is too long, cut it 1/16 to 1/8 inch above the metal surface. Before the rivet is cut, use a rivet set (hole over rivet) to draw the pieces of metal together.

(e) Make first few hammer blows straight down on the rivet to bulge the head. It may be necessary to peen the head that is formed from the shank or body of the rivet before using the rivet set.

(f) Use the rivet set to "buck" or shape the head solid against the metal.

(g) Set tubular split rivets with special rivet sets. The tool (rivet set) is used to spread the sides of the rivet and draw the rivet edges down firm on the metal.

(h) Blind rivets are used where only one side of the joint is accessible. Most blind rivets have a hollow core for a pin. However, there is one type with an explosive core that spreads after it is seated in a hole. To fasten the drive-pin type of rivet, drive the pin to a depth to spread the rivet.

Transparency No. 9

f. Washers

(1) Plain washers are usually used with many different types of bolts in woodwork. It is necessary to use washers on both ends of machine bolts and round headed stove bolts if two pieces of wood are joined together. The head end of a carriage bolt may not require a washer due to its having a round flat head. Washers help make bolts and screws complete fasteners when tying wood or metal to concrete, metal, and wood. Plain washers are known as flat steel washers. They are usually larger than the head or nut of a bolt; therefore, washers of this type distribute the stress load over a wider area than is usually distributed by the bolt head and nut. The size of a washer is determined by its outside diameter and the diameter of a hole. When selecting a washer, the hole should be about 1/32 inch larger than the bolt or screw size.

(2) Lock washers are used mainly to keep bolt nuts tight against a metal surface. Split-ring washers are used where vibration may cause the nut to loosen. They are made of spring steel and are cut with each end of the cut bent up to form tangs. The tangs bite into the nut or bolt head and the fastened part as the nut is tightened. The size of a washer is

and the fastened part as the nut is tightened. The size of a washer is determined by the size of bolt; therefore, the hole diameter is expressed in bolt and not washer size. Washers that are smaller than ¼ inch bolt size are identified by numbers that are used to identify machine screws.

(3) Toothed lock washers are used in the same way as split-ring lock washers. The teeth (external, internal, or external-internal) are hardened and bent in such a way that they dig into the metal on the bolt nut and the surface of the fastened part. The most common types of these washers are the external (teeth on outside) and internal (teeth on inside).

g. Nuts

(1) There are many kinds of nuts used in agricultural work. The most common types used include the square, hexagon, and castellated. The square nut is commonly used for agricultural work, especially on wood or wood and metal projects. Hexagon nuts are not commonly used for woodwork unless metal is part of the construction. Castellated nuts are also seldom used on woodwork. This nut has an outward slotted lip. When used with a cotter pin, the nut is secured in place; therefore, it is used mainly on power machinery where vibration is a factor.

(2) Common nuts are made of steel. Nut metal is usually softer than the metal in bolts. Many special nuts are made of alloy metals. The quality, dimensions, strength, and fit tolerances are regulated by the American National Standards Institute, the same as for bolts. Nut threads correspond to threads of bolts. The internal threads are fine and coarse. The dimensions of nuts include the inside diameter, thickness, and distance across flats (distance from one flat side to the other). Some common nuts are: square, hexagon, castellated, wing, speed, pal, cap, jam, self-lock, flanged, and spring.

Transparency No. 10

h. Pins, Rings, Keys, and Clamps

(1) Cotter Pin - Cotter pins are made of soft metal so that the prongs can be bent around a nut or other fastener.

(2) Spring Lock Pin - The spring lock pin is usually inserted into the hole drilled in a clevis pin after the clevis pin has been installed to hold parts together.

(3) Quick-Lock Pin - The quick-lock pin is commonly used when hitching an implement to the tractor drawbar and three-point hitch.

(4) Clevis Pin - The clevis pin is used to attach a part to a V-shaped yoke.

(5) Snap Ring - The snap ring is used for jobs such as securing the wrist pin in a piston or locking a bearing on a shaft.

(6) Key - Keys are used to secure items such as small engine flywheels, mower blades, and gears to a shaft. Keys are made of soft metal to allow for shearing. Keys should be installed in keyways with a soft or plastic hammer.

(7) Clamp - Various types of clamps are available and can be used to secure metal or hose.

Transparency No. 11

4. Removing Broken and Difficult to Remove Bolts

a. Many agricultural shops are not supplied with the various types and sizes of bolt extracting equipment necessary to remove any kind or size of bolt. Most bolts break at the surface of the hole, thus eliminating the use of any type of pliers or wrenches to extract the part left in the hole.

b. There are several methods used to remove broken bolts, and some of the most popular methods are:

(1) Screwdriver method

(a) Saw a slot across the broken stud bolt or cut a slot in the end with a cold chisel. It may be necessary to cut into the base metal to make the slot deep enough for a screwdriver.
(b) Back the broken bolt out by using the screwdriver.

(2) Punch and chisel method

(a) If the screwdriver method fails to remove the bolt, use a round nose punch or a flat chisel by placing the point in the slot on one side of the bolt.
(b) Tap the punch or chisel lightly to loosen the nut and finish removing it with a screwdriver or wrench. A large bolt (over 1 inch) and a small bolt (under ¼ inch) should be removed by some other method.

(3) The extractor method is used when the other two methods have failed. An extractor ("Ezy-Out") is made of hardened steel with left-handed spirals. Steps to follow in using an extractor are:

(a) Dent the center of the broken bolt with a center punch.
(b) Drill a pilot hole in the center of the bolt, then follow the pilot drill with the size of drill that corresponds to the shank of the screw extractor.

(c) Insert the extractor into the hole and turn counterclockwise to loosen the broken bolt or stud. A tap wrench or adjustable wrench may be used on the fluted end of the extractor.

(4) Other methods used to remove bolts

A hole is drilled in the stud (broken bolt) in the same way as drilling a hole to insert a screw extractor, except that the hole may be larger in diameter and deeper. A diamond point chisel is tapped lightly into the hole and the stud is backed out by using an adjustable wrench on the chisel body.

A large hole is drilled in the stud by following the steps for drilling a hole to accommodate a screw extractor. The stud wall is left thin so that it may be pushed in with a chisel or punch. A flat instrument (screwdriver, etc.) may be used to force the stud out by turning it.

The broken bolt may be drilled completely out and the hole retapped for a larger bolt. If the broken bolt is large (over ½ an inch) the hole may be drilled with three different sizes of drills including the pilot twist drill, in order to made the drilling easier.

Heat causes metal to expand and cold causes it to shrink. Heat also causes rust and other foreign materials to break loose from the metal. After a broken bolt is heated and cooled it may be easier to remove with a screw-driver, punch, chisel, or extractor.

The use of the proper size striking wrench is considered a successful way to remove bolts.

Sizes of Drills and Extractors to Use

Twist Drill Inches	Size of Bolt Inches	Extractor Size No.
5/64	3/16 - 1/4	1
7/64	1/4 - 5/16	2
5/32	5/16 - 7/16	3
1/4	7/16 - 9/16	4
1-1/16	1-3/8 - 1-3/4	8
1-3/16	1-3/4 - 2-1/8	9
1-5/16	2-1/8 - 2-1/2	10
1-9/16	2-1/2 - 3	11

(5) General information to observe when removing broken bolts is:

Protruding broken bolts may be removed by welding nuts on them and backing them out with a wrench.

The use of penetrating oil may aid the extraction of broken studs, especially if the studs are rusty.

If the threads inside a hole have been damaged, it may be necessary to retap the hole before using it.

Screw extractors are easily broken if too much pressure is applied while backing out a broken stud. If an extractor breaks, it may be necessary to remove it with a cold chisel or punch by breaking it into small pieces.

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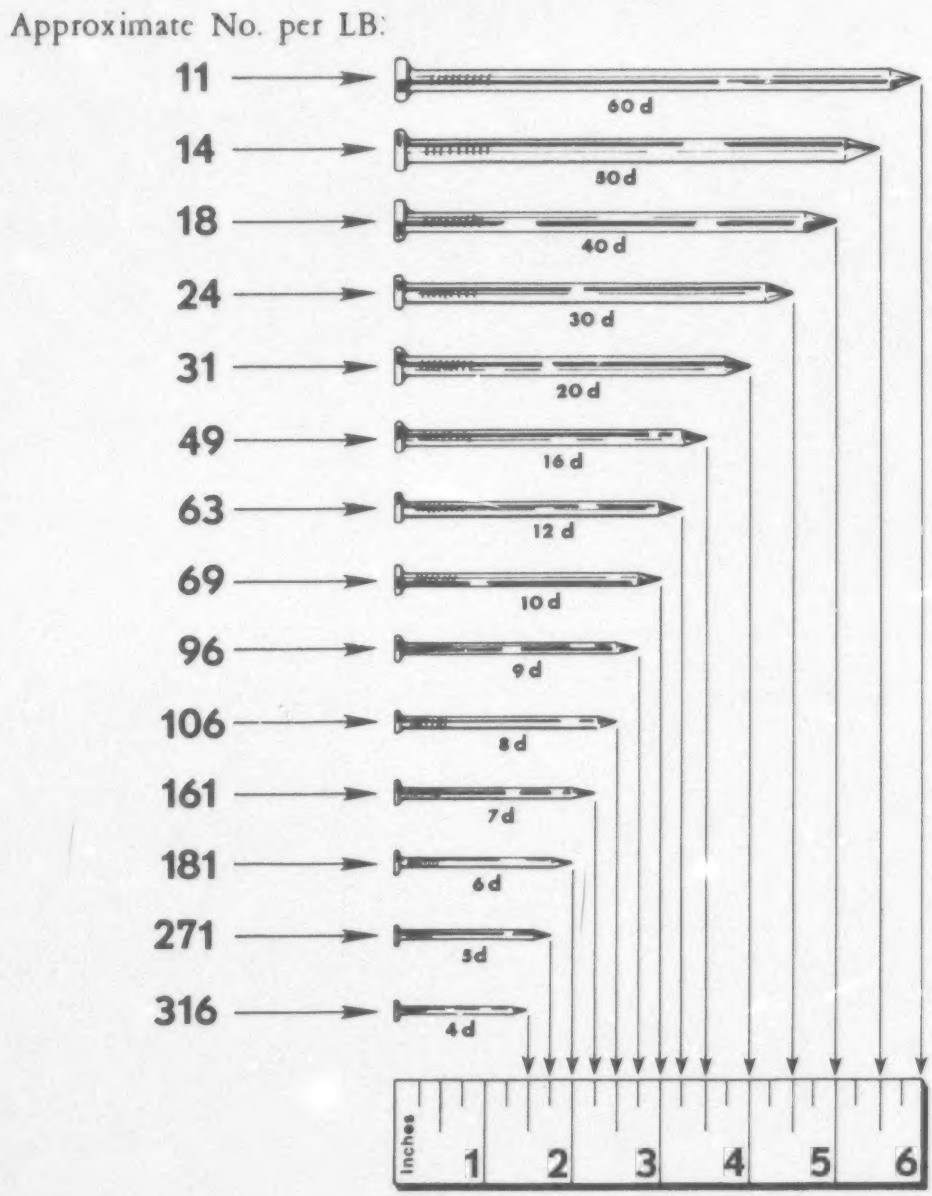
NAIL SIZES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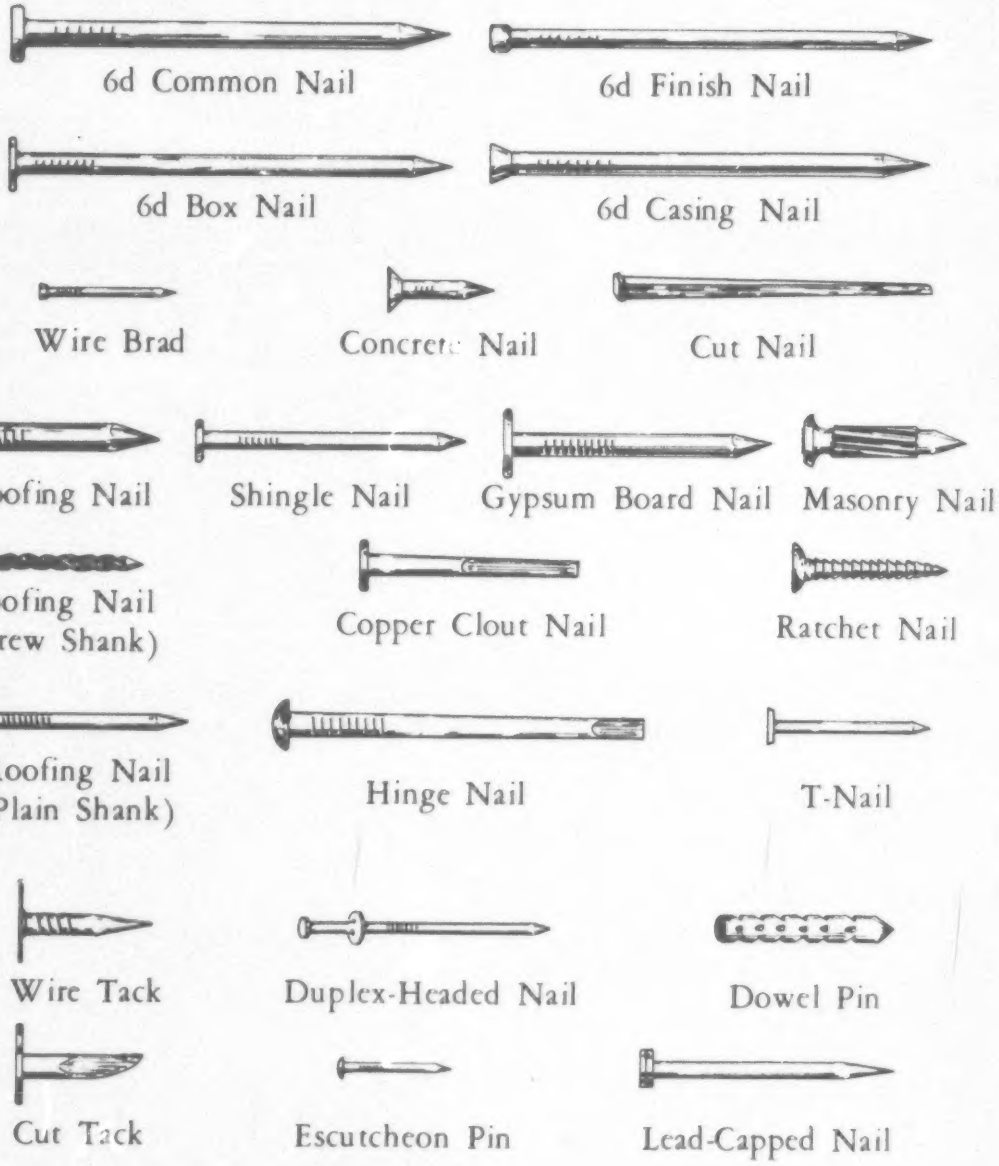
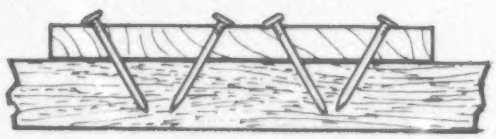
TYPES OF NAILS



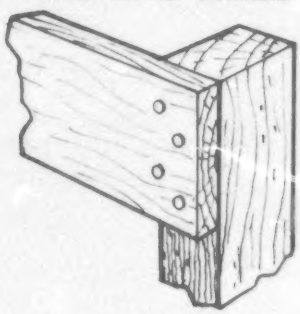
DRIVING NAILS

HOLD NAIL WITH THUMB & FOREFINGER

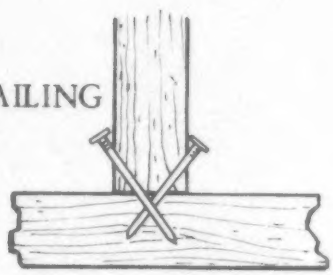


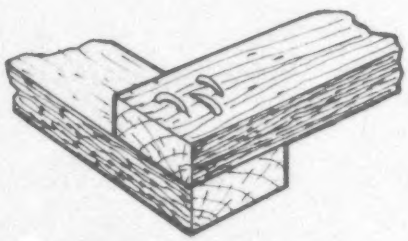
NAILS AT ANGLE
(give more strength)

ZIG ZAG NAILS

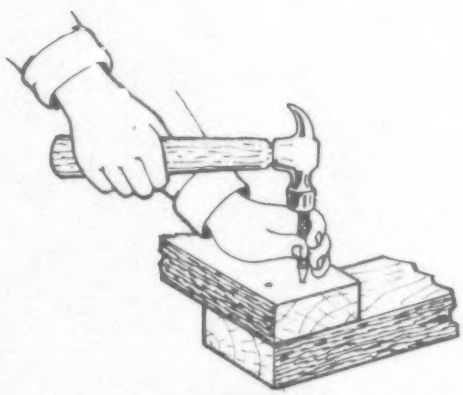


TOE NAILING



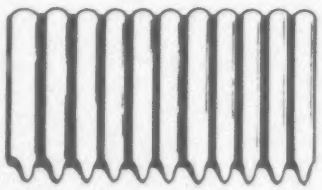


CLINCH NAILS
(across grain)

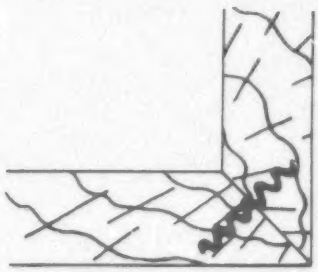


SET NAILS
(finish, casing, flooring)

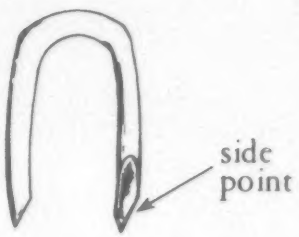
CORRUGATED FASTENERS & STAPLES



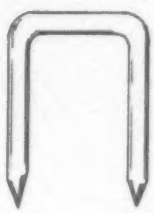
Corrugated Fastener



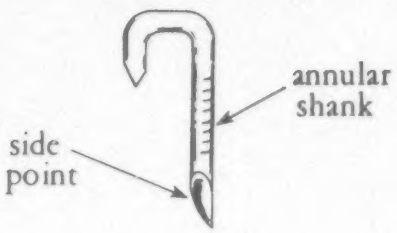
Use of Corrugated Fastener



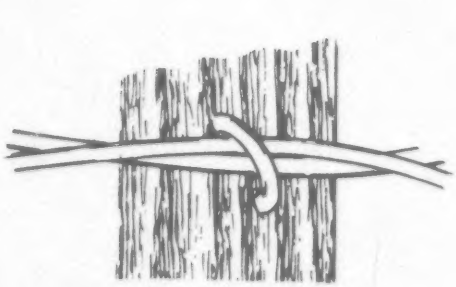
U-Wire Staple

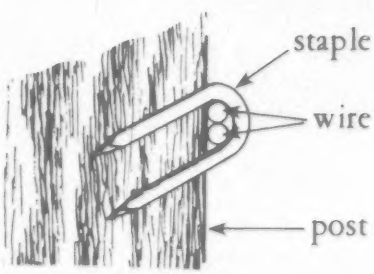


Wide Crown Staple



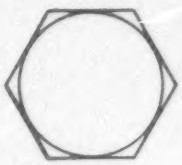
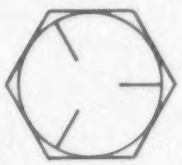
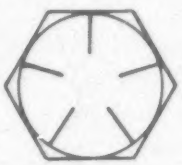
L-Fence Staple





Position of Staple in Fence Post

SAE GRADE MARKINGS FOR STEEL BOLTS

GRADE MARKING	SPECIFICATION	MATERIAL	TENSILE STRENGTH min., psi.
	SAE-Grade 0	Steel	
	SAE-Grade 1	Low Carbon Steel	55,000
	SAE-Grade 2	Low Carbon Steel	69,000*
	SAE-Grade 5	Medium Carbon Steel, Quenched & Tempered	120,000*
	SAE-Grade 7	Medium Carbon Steel, Quenched & Tempered	133,000
	SAE-Grade 8	Medium Carbon Alloy Steel, Quenched & Tempered	150,000

*Small size bolts. Larger bolts may have lower values.

SELECTING BOLTS

PLOW
(square shouldered)

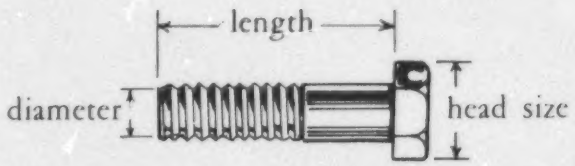
MACHINE
(hexagon)

CARRIAGE
(round)

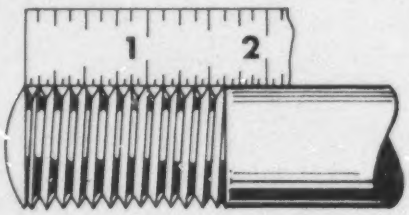
TWELVE-POINT

TYPES OF BOLT HEADS

HEX SOCKET



MACHINE BOLT



SCALE-THREADS PER INCH

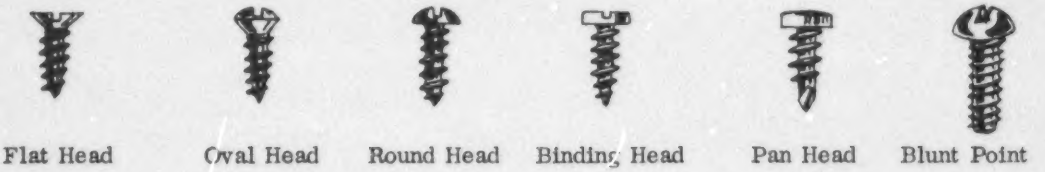
STUD

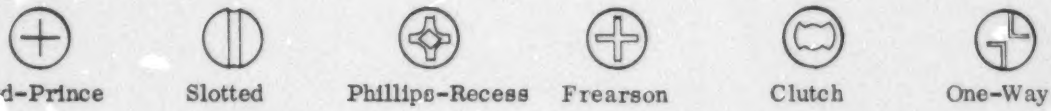
STOVE

LAG

OTHER TYPE BOLTS

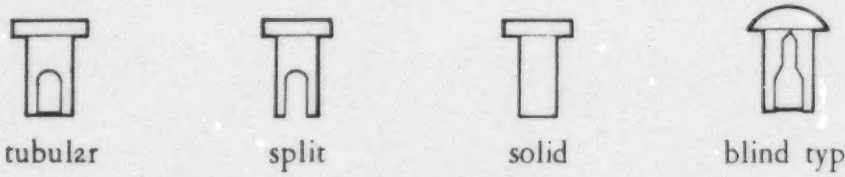
SCREWS & RIVETS





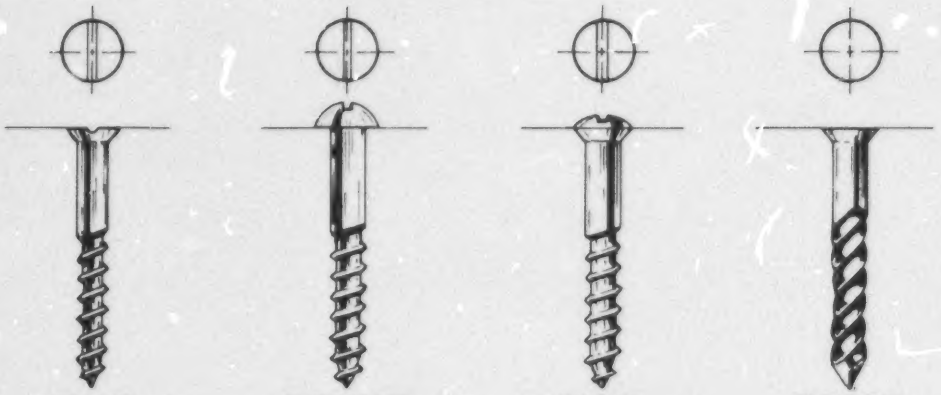
SHEET METAL SCREWS

MACHINE SCREWS

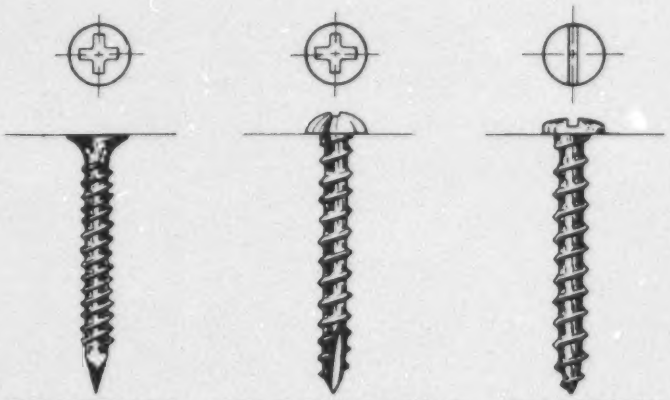


RIVETS

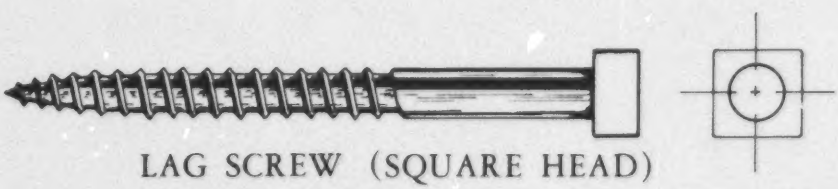
WOOD SCREWS



FLAT HEAD | ROUND HEAD | OVAL HEAD | DRIVE SCREW



DRYWALL PHILLIPS | SELF-DRILLING PHILLIPS | FILLISTER HEAD



LAG SCREW (SQUARE HEAD)

WASHERS & NUTS

WASHERS

Flat

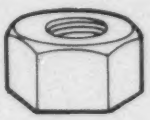
Lock

External Lock

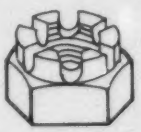
Internal Lock

NUTS

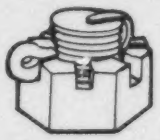
Square Nut



Hexagon Nut



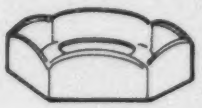
Castle Nut



Slotted Nut & Cotter Pin

Speed Nut

Wing Nut



Pal Nut

Cap Nut

Jam Nut

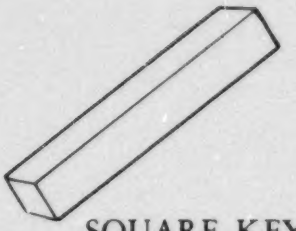
Self-Lock Nut

Flanged Nut

Spring Nut

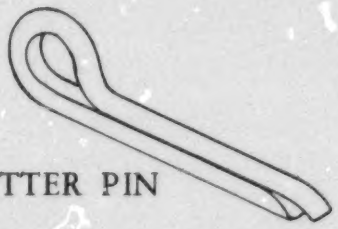
PINS, RINGS, KEYS & CLAMPS

SNAP RING



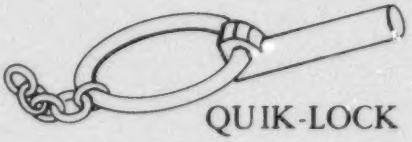
SQUARE KEY

WOODRUFF KEY



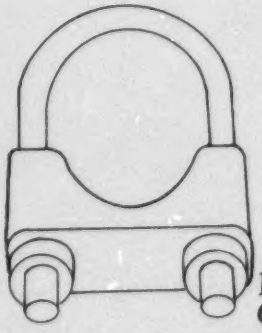
COTTER PIN

SPRING LOCK PIN

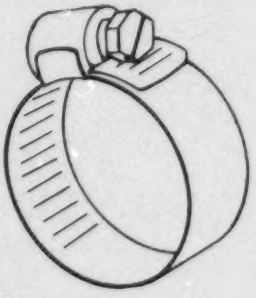


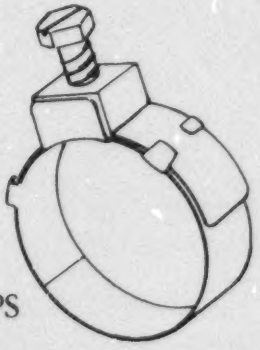
QUIK-LOCK PIN

CLEVIS PIN



METAL CLAMP

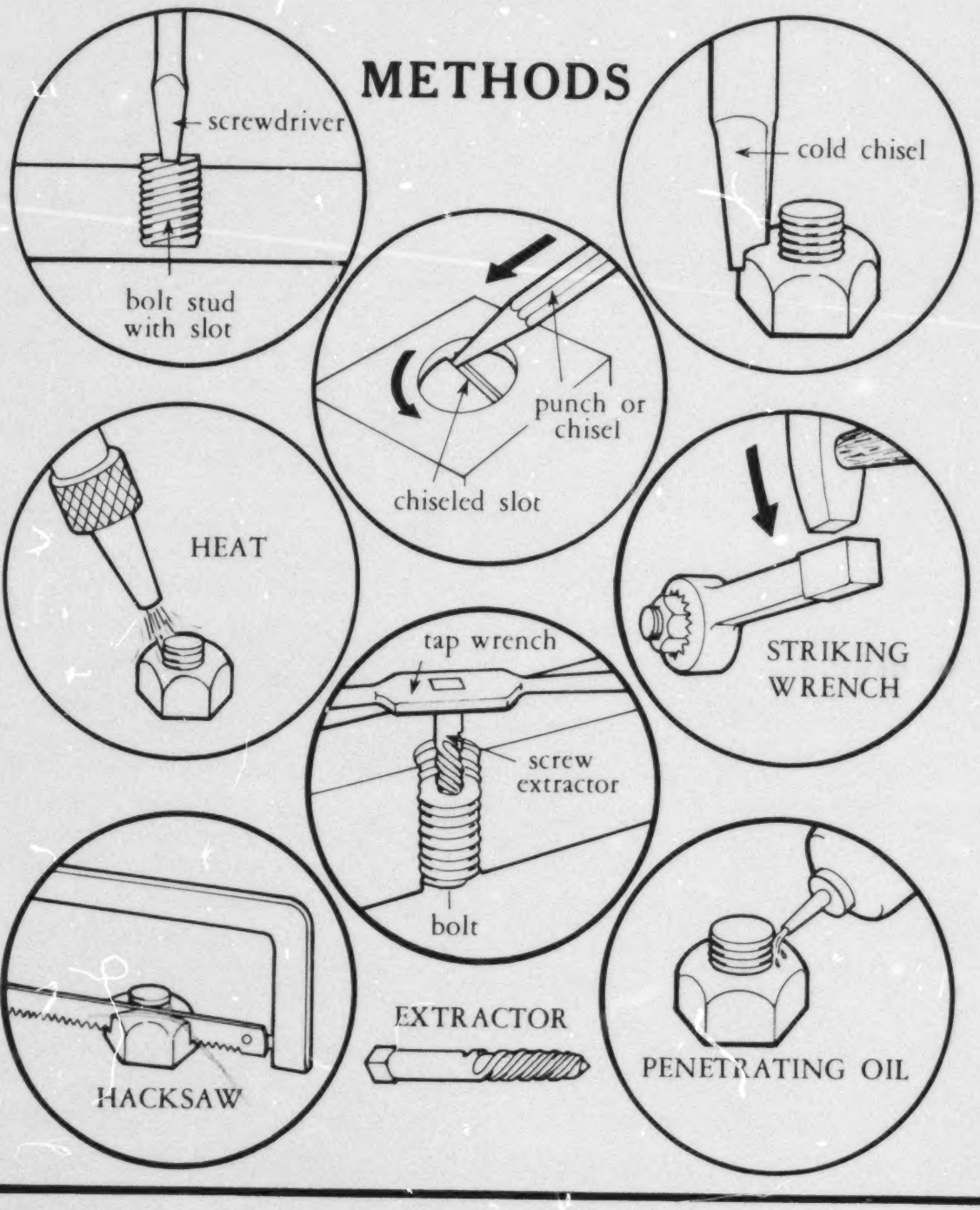




HOSE CLAMPS

REMOVING BOLTS

METHODS



CONSTRUCTION AND MAINTENANCE

Unit A: Introduction

Topic 6: Identification and Use of Building Materials

Suggested Procedure and Activities: Pieces of lumber showing the different grades; examples of kinds and sizes of nails, screws and bolts; samples of sand and gravel; various kinds of pipe; and samples of the kinds and sizes of electrical wiring will be helpful during the class discussion.

1. Three Major Kinds of Materials Used for Farm Construction

There are three important kinds of building materials used in farm construction. They are: wood, steel, and masonry. Wood and wood products are considered the most important building materials for livestock and poultry facilities, crop storage bins, barns, silos, and equipment storage facilities. Modern structures are planned so that they will not become outmoded in a short time. New buildings and equipment are constructed to be flexible, adaptable, portable, comfortable, and efficient.

As a farm grows in size, there is a greater need for adequate buildings and equipment. Simple buildings and scant equipment may hinder the farm business. On an established farm or ranch, most of the new structures are in the form of utility buildings, storage barns, production houses, feeders, pens, chutes, and pasture fences. In order for the farmer to be able to provide buildings and equipment, it is necessary that skills be developed in selecting materials.

2. Identification and Selection of Lumber

There are two main classifications of lumber: softwoods and hardwoods. Softwood lumber is cut from pine, cedar, fir, redwood, and cypress. Hardwood lumber is cut from oak, ash, birch, walnut, hickory, and maple. Most farm buildings are constructed of softwood.

There are two general grades of softwoods; select and common. The select grade is divided into four subgrades: A, B, C, and D. The common grade is divided into five subgrades: No. 1, No. 2, No. 3, No 4, and No. 5. Grades 4 and 5 are usually designated as utility grade.

The two highest grades of hardwoods are called FIRSTS and SECONDS. They are commonly sold together and designated as "FAS". The lower grades of hardwood are the same as for softwoods.

3. Description and Uses of Lumber Grades

The select grades, A, B, C, and D, are for the most part free of knots and blemishes. Select grade lumber is relatively straight grained and is used for fine finish work.

Common grade No. 1 is a general-purpose wood. It may have sound, smooth knots up to about two inches in diameter. Common grade No. 2 is often used for framing or flooring and has slightly larger knots and other blemishes. Common grade No. 3 has loose knots, occasional knotholes, and a limited amount of pitch and season checking. It is used sometimes for framing and shelving. Utility common grades No. 4 and No. 5 are poor quality and are used primarily for temporary structures and crating jobs requiring little strength.

Lumber may be purchased dressed on all four sides (S-4-S), dressed on one side and one edge (S-1-S-1-E), or finished to several other specifications. Rough-sawed lumber is considered to be of normal dimension if it measures full inches in thickness and width. Dressed lumber is a fraction of an inch smaller than rough lumber. For example, a dressed 1"x4" is actually 25/32" x 3 5/8" and a dressed 2 x 6 is 1 5/8" x 5 5/8". Lumber is usually sold in lengths of 6' 0" to 20' 0".

4. Types and Patterns of Lumber

Transparency No. 1

a. Common Boards: This lumber has square edges with different thicknesses, widths, and lengths.

b. Standard Patterns: (1) Dressed and matched or tongue and groove is known as center-matched. (2) Off-center matched is a tongue and groove cut for flooring. (3) Shiplap is a board with a rabbet cut on each edge. (4) Beveled siding is a board planed at an angle from one edge to the other. (5) Car siding has a V groove in the center and an angle cut on each edge of the grooved side. (6) Drop siding is a tongue and groove board that has a beveled cut on one tongue side. (7) Crib siding is beveled on each edge.

c. Board Lumber: This lumber is one inch or less in thickness.

d. Dimension Lumber: This lumber is normally 1 5/8" thick when dressed. It may be in 4", 6", 8", 10" and 12" widths.

e. Plywood: Plywood is found in 4 feet widths and 8 to 12 feet lengths, with ¼" to 3/4" thickness by units of 1/8". There is exterior and interior plywood.

f. Hardboard: This board is made of wood fibers. It is 4' in width and 4 to 12 feet in length. The most popular thicknesses are 1/8" and 1/4".

5. Description of Plywood

Plywood is a built-up board made by assembling the veneers with the grain of each

layer, or ply, at right angles to the ones adjacent to it. The kiln-dried veneer is united under high pressure with an adhesive producing a bond between layers as strong as, or stronger than, the wood itself. An odd number of veneers --- three, five, seven --- is used so the grain direction on the face and back of the panel run in the same direction.

Wood is strong along the grain, but somewhat weaker across the grain. Cross-lamination distributes wood's along-the-grain strength in both directions, creating a panel that is very strong for its weight, split-proof and puncture-proof. Peeling veneers from a log and reassembling them also provides a means for making panels much larger than could be produced by sawing.

6. Types of Plywood

In general, "type" refers to the glue durability and bond that can be expected when plywood is used in various applications.

(a) Exterior-type plywood has a waterproof glue and veneers selected for producing a bond between plies that is stronger than the wood itself. This type is the ultimate in moisture resistance as the glue cannot be weakened by time, weather, or even boiling water.

(b) Interior-type plywood has either highly moisture-resistant or waterproof glue, at the option of the manufacturer. Veneers used in the inner plies and backs, however, are not as high quality as required for Exterior-type. It will withstand occasional wetting during construction, but should not be permanently exposed to the elements.

7. Grades of Plywood

a. Plywood is graded by the appearance quality of the veneer on the face and back of the panel. There are six grades of veneer as follows:

"A" Best standard veneer. Smooth and paintable. May be more than one piece, well jointed. Neatly made repairs permitted.

"B" Solid surface veneer. Circular repair plugs and tight knots permitted. Can be painted.

"C-Plugged" Improved "C" Veneer Underlayment grade.

"C" Minimum veneer permitted in Exterior-type. Knotholes to 1", splits, plugs, and other repairs permitted. (Occasional knotholes ¼" larger permitted provided total width of all knots and knotholes within a specified section do not exceed certain limits.)

"D" Used only for inner plies and backs of Interior-type. Knotholes up to 2-½"

in maximum dimension and an occasional knothole ½" larger under certain specified limits.

"N" Special order "natural finish" veneer. Select, all heartwood. Free from open defects. Allows some repairs.

b. These veneer grades are combined to form the following plywood grades:

EXTERIOR-TYPE				INTERIOR-TYPE			
Grade	Face	Back	Inner Plies	Grade	Face	Back	Inner Plies
A-A, Ext.	A	A	C	A-A, Int.	A	A	D
A-B, Ext.	A	B	C	A-B, Int.	A	B	D
A-C, Ext.	A	C	C	A-D, Int.	A	D	D
PlyForm, Class I & II,				B-B, Int.	B	B	D
B-B	B	B	C	B-D, Int.	B	D	D
B-C, Ext.	B	C	C	Int. Underlayment	C*	D	C & D
C-C, Ext. (Plugged)	C*	C	C	C-D (plugged) Int.	C*	D	D
C-C, Ext.	C	C	C	Structural I C-D Int.	C	D	D
Structural I C-C Ext.	C	C	C	Structural II C-D Int.	C	D	D
				Standard Int. (Exterior glue)	C	D	D
				Standard Int.	C	D	D

* C veneer that has been plugged.
Plywood is purchased by the sheet or square foot.

8. Selecting Fasteners

a. Nails are the most common kind of fasteners for lumber structures. Nails may be purchased with galvanized zinc or cement coating. The most common types of nails and their uses are:

Common: Fastening rough carpentry boards of various sizes.

Casing: Fastening tongue and groove and finish work.

Finish: Fastening wood in finish work.

Roofing: Fastening composition shingles and other roofing material.

Annular Grooved and Spirally Grooved: Fastening metal or steel sheets on roofs and sides of buildings.

Shingle: Fastening wood shingles on roofs of buildings.

Box: Fastening boards that may split easily. Smaller in diameter than common nails.

Plasterboard: Fastening plasterboard.

b. Screws are usually considered more secure than nails. There are three major types of screws. They are: wood, metal, and leg screws. The wood and metal screws may have oval, flat, and round heads. The leg screw is used with expansion shields to fasten wood to masonry materials.

c. Bolts are used as fasteners in the construction of buildings and equipment where permanency and strength are important factors. They are also used in many prefab structures and certain types of equipment that are dismantled frequently. The most common types of bolts used on the farm are: carriage, machine, stove, and plow.

Carriage and Machine Bolts: These are used for heavy wood construction such as fastening heavy boards when building trusses and fastening sills or plates to foundations.

Machine Bolts: Used as fasteners for lightweight metal or wood structures.

d. Other fasteners are as follows:

Hinges: Straps, T, butt, screw, hook strap, hasp and eye, and cabinet.

Other Hardware: Door pull, corner brace, metal anchors, screw eye and hook, screw hook, door, window, and gate latches.

9. Building Materials for Utility Buildings

Transparencies Nos. 2 and 3

The most common utility buildings are constructed of treated poles, heavy lumber, with metal roofing and sides. Some of these structures have concrete floors, whereas others have dirt floors.

The use of steel for buildings has continued to increase during the past two decades. There are many types of prefabricated steel buildings on farms. One of the most common types of prefabricated buildings is the semicircular roof. Pole type utility structures have either a shed or gable roof.

The materials used for utility buildings are listed below:

a. Steel, treated lumber, or treated posts of a variety of sizes are used as studs.

b. Galvanized steel or aluminum, either corrugated or 5-V crimp sheets are used as roofing and/or siding. The standard length is from 6 to 16 feet and the width 26 to 26½ inches.

c. Steel or wood is used for trusses, joists, sills, and lintels (support over opening).

d. Posts or studs are set in good quality concrete or graveled bottom holes. Studs may be set on a concrete floor, concrete foundation, or other type of concrete support. The type of studs used will depend upon the permanency of the structure, funds available for the structure, type of structure, and the use of the structure.

e. Concrete blocks, bricks, and wall tile are used to a limited extent on farm utility buildings. Most masonry structures are constructed of concrete blocks. The concrete blocks measure about 8" x 8" x 16". The following types of blocks may be selected for building purposes; regular or stretcher, corner, jamb, header, partition, and beam or lintel. The type of mortar mixture used will depend upon the type of masonry material used. Masonry buildings are also constructed by using prefabricated concrete wall panels. Again, the type of masonry structure used on a farm will depend on its use, cost, and permanency.

10. Selecting Fencing Materials

Before selecting materials for a fence the following conditions should be considered:

a. The purpose of the fence. Type of livestock on the farm.

b. Permanency of the fence. Whether the fence is to remain in its original location for several years or be a temporary (movable) fence.

Transparencies Nos. 4a and 4b

c. The approximate life of the fence, the gauge of wire, type of posts, method of construction, method of upkeep, and climatic conditions all affect the life of a fence. For example, 12½ gauge wire will last longer than 14 gauge wire; treated posts have a longer life span than untreated lumber; suspension fences usually require less maintenance than non-suspension fences; and woven wire fence maintenance is higher for large animals than small animals. Table 1 shows the types of material to use.

The type of fence fastener used will also affect the life of the fence. Untreated red cedar requires a staple length from 1" to 1¼". Staples from 1½" to 2" are recommended for treated posts. Fluted shank, helically-threaded shank, and annularly threaded shank nails are recommended for permanent board fence fasteners.

11. Selecting Paints

Paints have been developed for all types of structures. The kind of paint selected will depend mainly on the type of material to be painted. For example, the steel surface of machinery is painted with a rust inhibiting paint (red or blue lead

plus linseed oil), known as the primer coat, before applying additional coats of paint, an aluminum paint may be used as a primer coat for wood or to prevent creosote or red paint from bleeding through.

The most common kinds of paints used on buildings and equipment are:

Exterior house paints
Interior house paints
Floor paints
Roof paints
Enamel paints
Barn paints
Masonry paints
Metal or implement paints

First, paint should be selected for its protective values on wood, metal, or masonry surfaces, and secondly, it should be selected for decoration purposes.

12. Suggestions for Selecting Electrical Wiring Materials

Transparencies Nos. 5a and 5b

a. Wire must be large enough in diameter to carry the electrical load. The size or gauge is determined by a number. Small numbers indicate large wires. To wire a building properly, the distance from yardpole to building and the amperage load must be known.

b. Rigid conduit should be used where moisture-proofing is necessary. It resembles water pipe.

c. Plastic cover cable may be used in masonry walls for exterior, interior, and underground wiring. Nonmetallic sheathed cable is used for indoor wiring on many farms. However, it is not moistureproof unless it has been treated.

d. Fire and moisture resistant armored cable should be used where many cable bends are necessary. In some cases a lead sheathed cable is used for underground wiring.

e. Other suggestions are as follows:

Use duplex type convenience outlets.

Use porcelain or bakelite plates to cover the switches.

Use three-way toggle switches at entrances and exits.

Four-way switches may be used with three-way to control lights from three or more locations.

Building plans are the main source of information for the kinds and amount of wiring materials that should be purchased.

13. Selecting Pipe, Pipe Fittings, and Plumbing Fixtures

Transparency No. 6

a. There are five major kinds of pipe and pipe fittings used on the farm. They are:

Steel. The two types of steel pipes and fittings are black and galvanized. Black pipe is used for gas and oil, and galvanized is used for water systems. Galvanized pipe resists corrosion.

Plastic. Plastic pipe and fittings are usually used to carry water from the main water supply (well or main line) to the water outlet fittings. Plastic pipe is not as durable as gavanized pipe if exposed to animal traffic or heavy machines passing over it. It is also resistant to corrosion. Plastic pipe is usually cheaper than other types of pipe.

Cast Iron. Cast iron pipe and fittings are similar to plastic pipe, in that they resist corrosion when used as water mains, placed underground, and have a long life, if installed properly. Large size cast iron pipes and fittings are used mainly as drainage and vent pipes. Drain and vent pipes are also made of copper and plastic.

Lead Pipe. This pipe may be used as an underground water pipe unless the water contains a mineral that may react with the lead, causing a poisonous water.

Copper Tubing. Copper tubing is the most expensive type of pipe. It is joined together by soldering and flared fittings. The same amount of fittings are used on copper pipe as any other type of pipe. Copper is used in the interior of some farm homes.

Other Pipes. Cement-lined wrought iron, brass, brass-copper, tin-lined lead, and tin-lined cement pipes are used less often than the five major types.

b. Plumbing fixtures vary in cost according to size, style, and quality of material used in making the fixture. For example, a hot water heater with a 40 gallon capacity costs more than a 30 gallon heater. A 10 year warranty fixture will cost less than a 15 year warranty fixture. The longer life fixture usually contains a better quality of material and workmanship.

References:

Ashby, Wallace and Others. Modern Farm Buildings, Prentice - Hall, Inc., Englewood cliffs, N. J. 1959.

Phipps, Floyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, IL 1967.

"Planning Farm Fences", American Association for Vocational Instructional Materials, Athens, GA 1970.

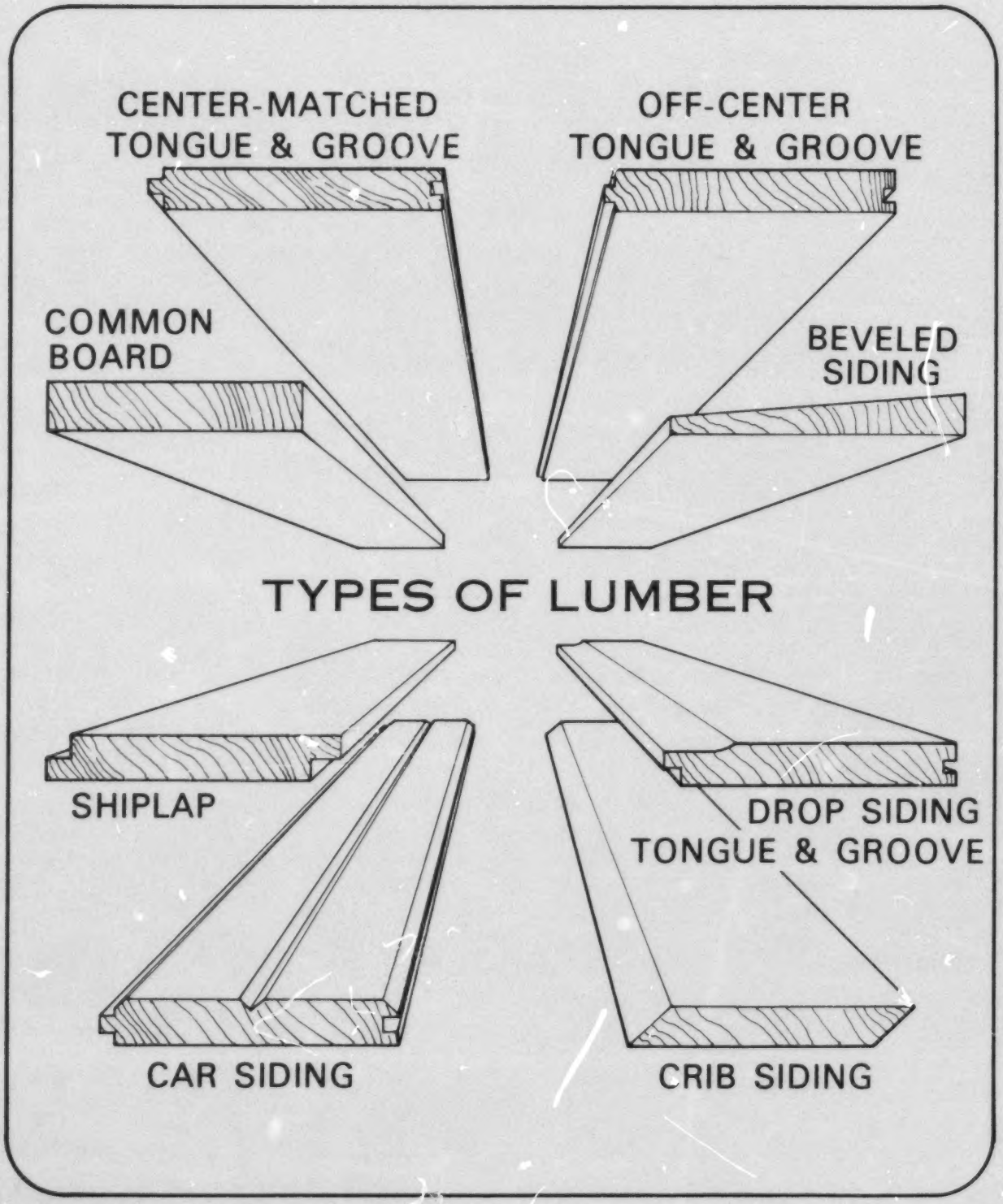
"Plumbing-Planning and Installing", Sears, Roebuck, and Company, Dallas, TX 1967.

"How To Buy and Specify Plywood", Form No. 66-410, American Plywood Association.

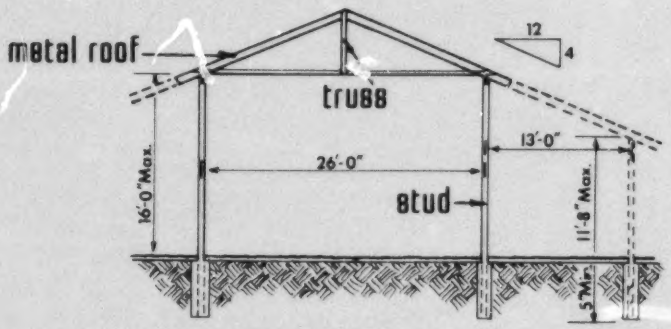
SELECTING FENCING MATERIAL

Table 1

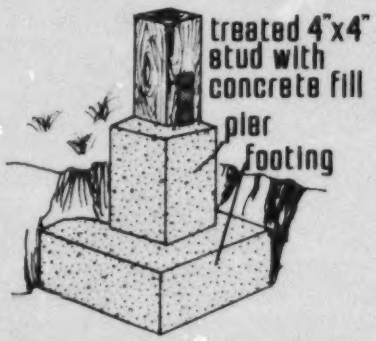
Type of Material	Approximate Life Years	Maintenance	Type of Fence
4 Strands, 12 1/2 gauge	33 to 59	High	Barbed Wire
4 Strands, 14 gauge	19 to 33	High	Barbed Wire
4 Strands, 12 1/2 gauge	33 to 59	Medium	Suspension Wire
Light Weight, 14 1/2 gauge	19 to 33	High	Woven Wire
Medium Weight, 12 1/2 gauge	33 to 59	Medium	Woven Wire
Heavy Weight, 11 gauge	40 to 60	Low	Woven Wire
1" x 6" Boards (pressure treated)	20 to 30	Low	Board
2 Strands, 17 gauge	17 to 32	Medium	Electric (movable)
Southern Pine Posts (untreated)	3 to 7		
Southern Pine Posts (pressure treated)	25 to 30		
Steel and Concrete Posts	20 to 30		


CENTER-MATCHED
TONGUE & GROOVE
OFF-CENTER
TONGUE & GROOVE
COMMON
BOARD
BEVELED
SIDING
TYPES OF LUMBER
SHIPLAP
DROP SIDING
TONGUE & GROOVE
CAR SIDING
CRIB SIDING

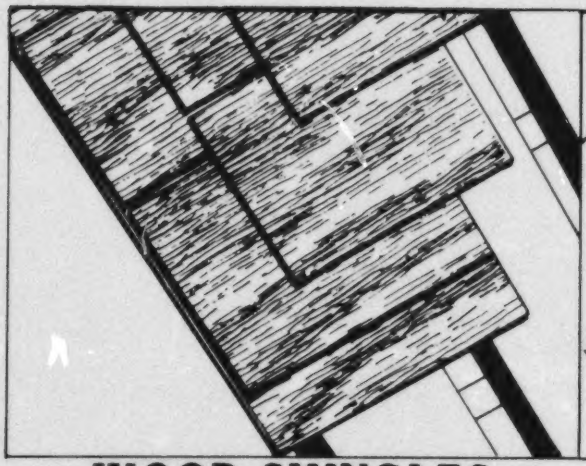
UTILITY FARM BUILDING



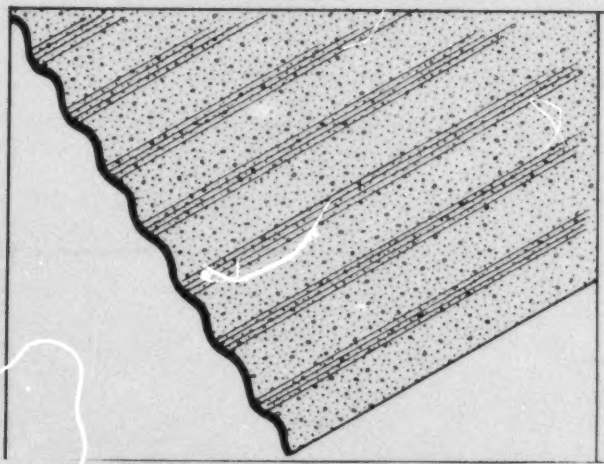
END VIEW



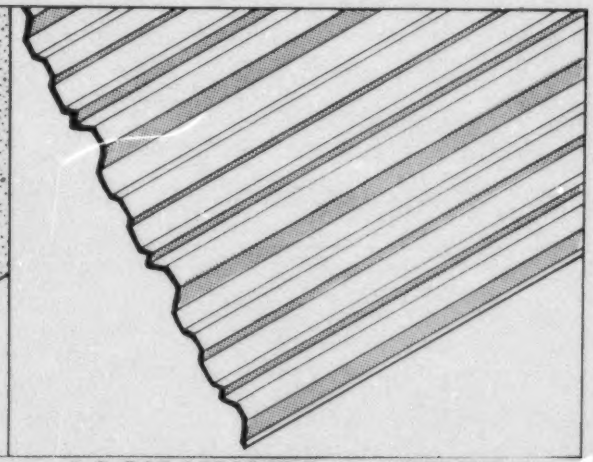
ROOFING MATERIALS



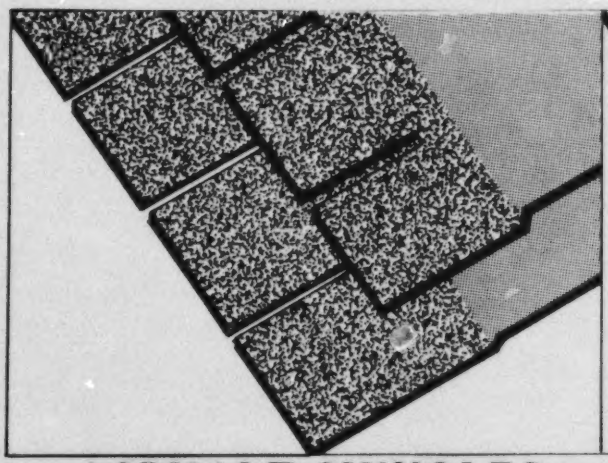
WOOD SHINGLES



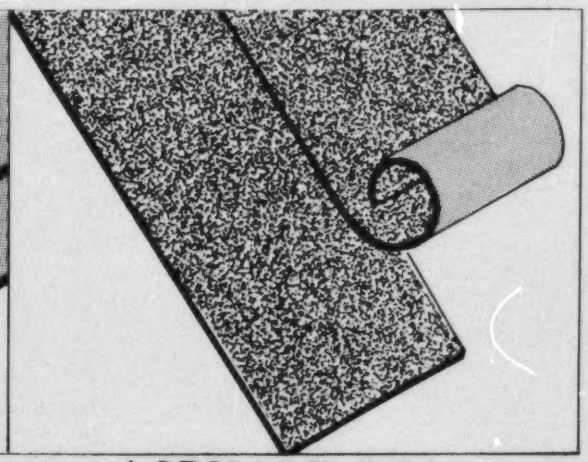
ASBESTOS CEMENT



ALUMINUM or STEEL

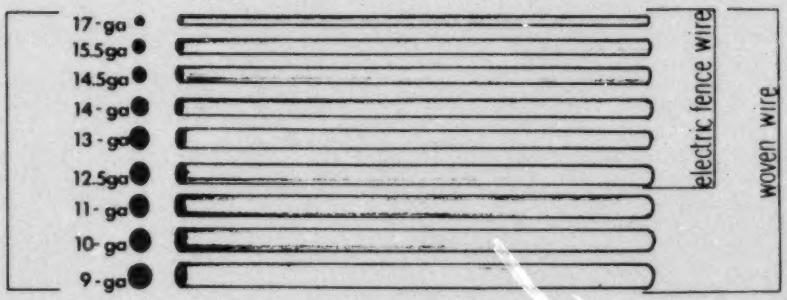


ASPHALT SHINGLES



ASPHALT ROLL

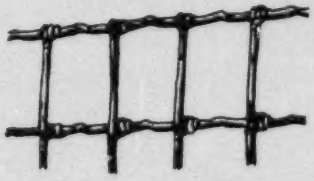
FENCING MATERIALS



WIRE SIZES

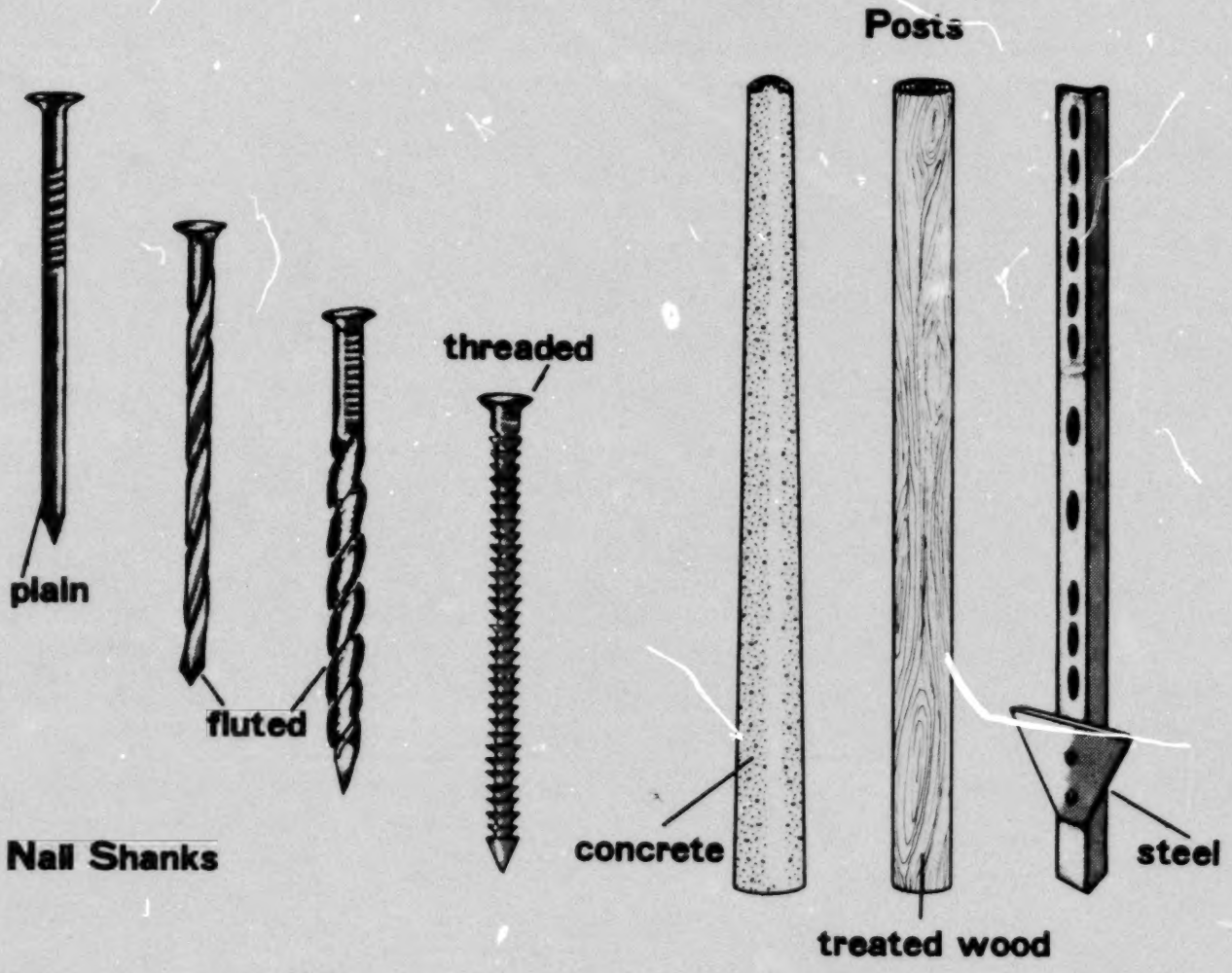
Barbed Wire
sizes 12½–14 ga.

Fence Staple

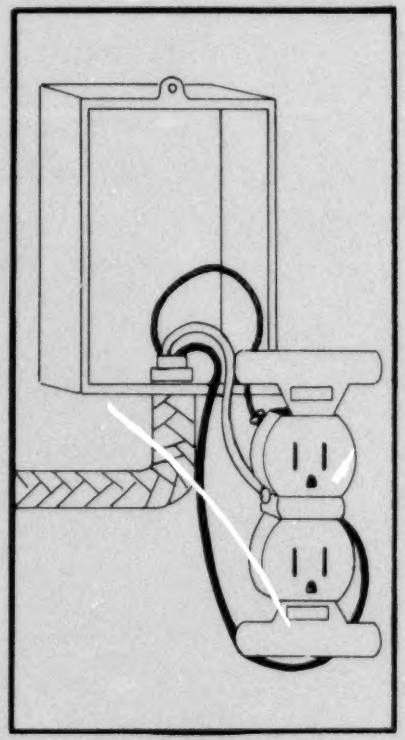


Woven Wire

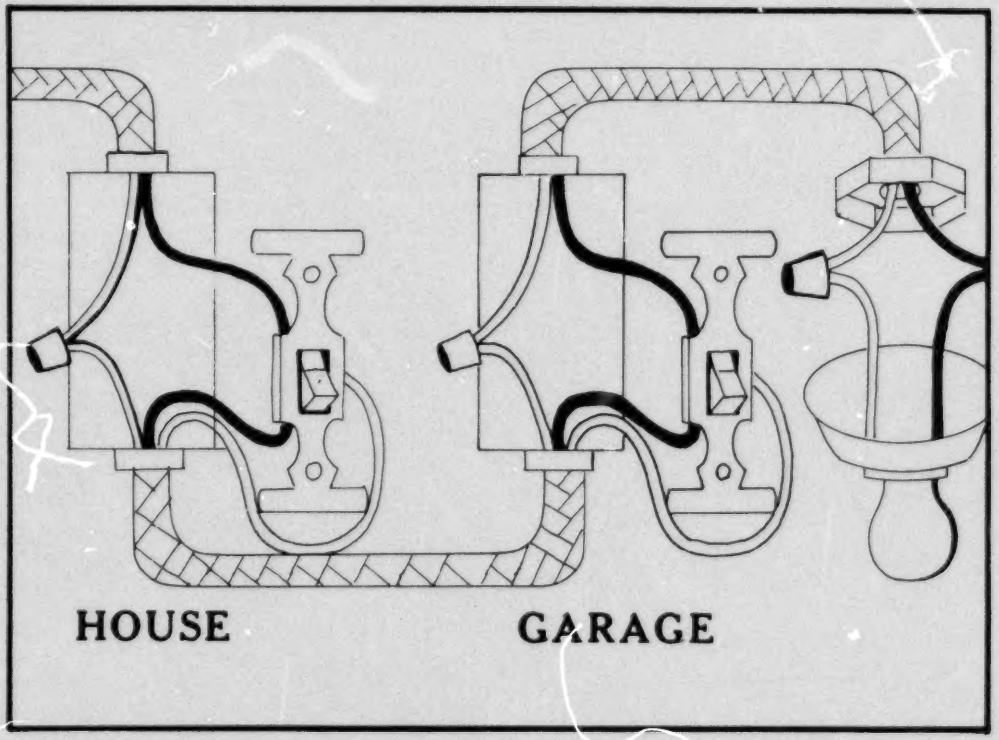
FENCING MATERIALS



WIRING MATERIALS



DUPLEX OUTLET



THREE-WAY SWITCH

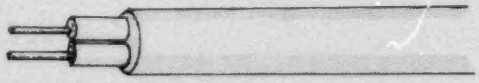
WIRING MATERIALS

actual size of wire

0 1 2 4 6 8 10 12 14

size to use		
pole to bldg.	load in amperes	size of wire
up to 50 ft.	up to 25A-120V	no.10
50 to 80 ft.	" " "	no. 8
80 to 125 .ft	" " "	no. 6

rigid conduit

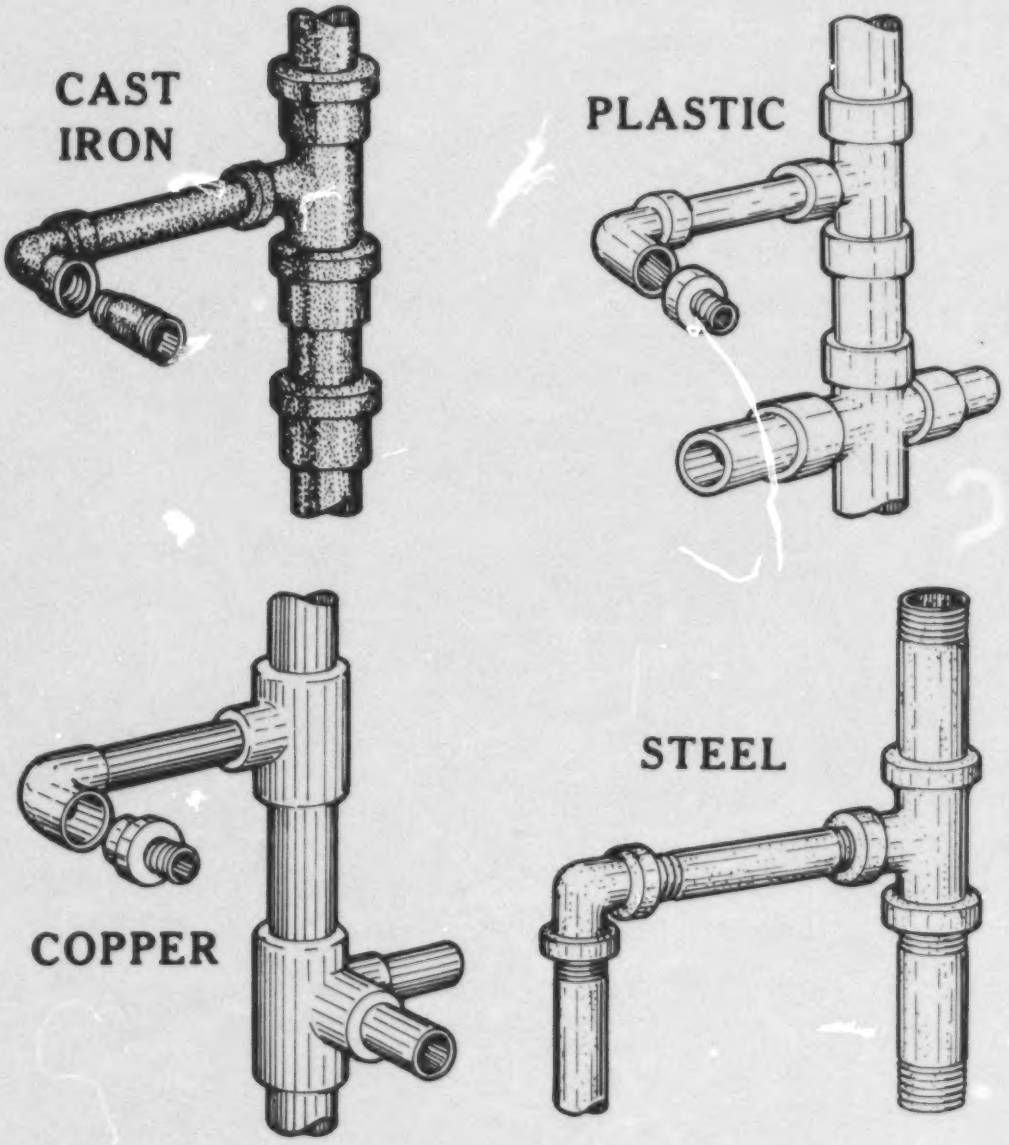


dual-purpose plastic cable

indoor plastic cable

armored cable

PIPE & PIPE FITTINGS



CONSTRUCTION AND MAINTENANCE

Unit A: Introduction

Topic 7: Identification and Use of the Farm Level

Suggested Procedures and Activities: A number of laboratory exercises may be conducted from the information presented in the topic. It is suggested that the teacher conduct a number of the exercises in order to give the students practice in using the level and tripod.

1. Kinds of Tripod Levels

There are several kinds of tripod levels which vary considerably in quality, cost, and accuracy. The most common types of tripod levels are the wye, dumpy, architect, drainage, and farm level.

The wye level is the most expensive and gets its name from the method used to attach the telescope to the rest of the level. The telescope, attached by two wyes, may be easily removed and adjusted. This level may have either three or four leveling screws.

The dumpy level has a bubble tube attached to the telescope which is difficult to remove from the rest of the level. It is cheaper and easier to adjust than the wye and may have either three or four leveling screws.

The architect and drainage levels are similar to the dumpy and have plumb bob attachments (an attachment used to mark a point).

The farm level is also similar to the dumpy level. It is adequate for most farm jobs, inexpensive, simple to use, accurate, and with proper care will give excellent service. The two types of farm levels are the turret and the utility. The turret type has three leveling screws, while the utility type has four leveling screws.

2. Transporting the Tripod Level

A level must be handled and transported properly if it is to be accurate and give service. Suggestions for handling and transporting a level are as follows:

1. The level should be protected from shock and vibration;
2. The level should be kept in its box except when it is being used;
3. The level should be screwed firmly and with care when fastening it to the tripod;

4. The level and tripod should be carried on the shoulder except when walking through brush, then it should be carried under the arm;
5. The moving parts should never be forced;
6. The leveling screws should be snug against the leveling plate;
7. The lens on some levels should be protected from the direct rays of the sun by using a sun shade;
8. The lens should be cleaned with a soft cloth or tissue;
9. The lens should not be removed from the telescope; and
10. The tripod nuts should be loosened before picking the instrument up or setting it down.

3. Checking and Adjusting the Level

A vocational agriculture student should become familiar with the different parts before using the level. These are shown in the following transparency.

Transparency No. 1

The following steps should be used in setting up the level:

1. The tripod legs should be set firmly and at least 3 1/2 feet apart;
2. The wing nuts should be tightened on the tripod head;
3. The level should be securely screwed to the tripod head;
4. One of the tripod legs should be spiked firmly in the ground;
5. The telescope should be turned over the spiked leg and one of the other legs, and the second leg should be spiked and moved in or out until the bubble is visible in the bubble tube;
6. The level tube is turned over the third leg, and it is spiked and moved in or out until the bubble is visible in the bubble tube; and
7. The leg nuts should be tightened on the tripod legs.

Before leveling the instrument, the leveling screws are placed in the mid position in the bosses. This places the center spring under light tension and allows the screws to be raised or lowered as needed. The turret should turn freely.

Leveling the Turret Type Level - The steps in leveling the turret type level are as follows:

1. The telescope is placed over two of the leveling screws, and the bubble is centered by turning the leveling screws equal distances in opposite directions. This may be accomplished by moving the thumbs toward or away from each other.

2. The telescope is set directly over the third screw, and the bubble is centered by turning the third screw.

3. The leveling process is repeated in each of the above steps until the bubble remains centered in the bubble tube.

Leveling the Utility Type Level - The procedure is as follows:

1. The telescope is placed over two diagonally opposite leveling screws, and the bubble is centered by turning the screws equal distance in opposite directions. The thumbs should be moved toward or away from each other.
2. The telescope is turned over the other two diagonally opposite leveling screws, and the bubble is centered.
3. The leveling process is repeated in each of the above positions until the bubble remains centered in the bubble tube.

The farm level should be checked for accuracy each time before it is used. The parts that should be checked are the bubble tube, telescope, and cross-hairs. The turret type and utility type levels are checked in the same manner.

Bubble Tube - The bubble tube is checked as follows:

1. The bubble tube is placed over two of the leveling screws, and the screws are turned in or out until the bubble comes exactly between two corresponding vial lines.
2. Then the turret is swung 180 degrees so that the bubble tube is end for end from the first position. If the bubble does not come exactly to the center between the vial lines as at first, one-half of the amount is corrected by the same two leveling screws. The other half of the difference should be adjusted by the level vial screws shown in the transparency.

The three screws that hold the turret in place should be screwed out to remove the turret and telescope.

Transparency No. 2

The bottom screws on the low end of the tube are loosened and the top screws are tightened. The test and adjustment should be repeated until the bubble stands between the vial lines regardless of the direction the level vial tube is turned. The bubble tube on the utility level is adjusted with two vial screws shown in transparency.

Telescope - There are two tests that should be conducted on the telescope. One is testing the telescope by inverting the turret, and the other is by testing to see if the line of sight is level when the bubble is centered. The first test is made after the instrument is leveled by focusing the telescope on a definite spot 200 to 300 feet in the distance with the turret in the correct position. The turret is then inverted and a sight is taken on the spot. If the center of

the horizontal cross-hair remains on the spot, it is properly adjusted. If the telescope needs adjusting, the small screws at the front (where the telescope goes through the turret) should be adjusted to eliminate half of the error. The process should be repeated until the reading remains the same with the turret in the correct position and in the inverted position.

The second test (a test to see it the telescope is in the line of sight of the level when the bubble is centered) is conducted as follows:

1. Stakes A and B are driven in the ground 100 feet apart, or some other convenient distance. In the same line but in the opposite direction, Stake C is driven in the ground. The distance between AC and AB should be equal, and the tops of stakes B and C should be set at the same level.
2. The instrument is set over Stake A and the rod is held on Stake B. The target rod should be adjusted so that the horizontal cross-hair bisects the target.
3. The target setting is read and recorded.
4. The target setting is not changed, and the rod is moved to Stake C.
5. Stake C is moved up or down until the cross-hair bisects the target when the rod is held on Stake C and the bubble is in the center of the tube. If it is necessary to raise the stake, it should be pulled up too far and gradually driven into the ground until it is the correct elevation. The accuracy of the test depends on the stakes being at the same level.
6. Then the instrument should be moved to within three or four inches of Stake B and leveled.
7. The rod then is set on top of Stake B, and the target is adjusted until the cross-hairs bisect the target.
8. Then the target rod is left at this setting and carried to Stake C where it is placed on top of Stake C, and a reading is taken. If the cross-hairs bisect the target, the line of sight is level when the bubble is centered. If the cross-hairs do not bisect the target, the telescope should be adjusted by the screws at the front of the level frame. The front end of the telescope is raised by unscrewing the bottom screw and tightening the top screw. The telescope is lowered by moving the screws in the opposite direction.

Testing the Cross-Hair - The cross-hairs are tested after the instrument is leveled and the telescope is adjusted, which is accomplished by moving the slide tube in or out until the object comes in focus. The horizontal cross-hair is focused on a definite point, and the level is rotated back and forth slightly from side to side. If the ends of the cross-hair remain on the point in the same place as the center, the cross-hair is in adjustment. If the cross-hair is out of adjustment, the instrument should be sent to the company to have it adjusted.

4. <u>Using the Target Rod</u>

Three types of target rods are the Philadelphia, architect, and self reading rod.

Transparency No. 3

The Philadelphia rod is graduated in feet, tenths, and hundredths; and the architect rod has the same graduations, but is much lighter and shorter. The self-reading rod is graduated in feet, tenths, and hundredths and is used principally for surveying land, running drainage lines, and general soil conservation work.

The Philadelphia and architect target rod have extensions. The target must be set at the same reading on the face of the rod before it is extended to equal the lowest reading on the back of the extended rod. The target should always represent a true reading and should be raised to the top of the unextended rod section before the rod is lengthened. The target rod has very few parts, but a student should become familiar with the parts and their function if he is to use the rod properly.

The rod is used to measure elevation or comparative heights of objects in their relation to the height of the instrument. For example, a rod reading of three feet at one point and five feet at another point is a difference in elevation of two feet at these two points. Grades are established by moving the target a distance over the ground. The grade is raised when the target is lowered, and the grade is lowered when the target is raised.

Instructions to Rodman - To hold the rod, the rodman stands behind the rod and holds it in a vertical position. If the rod is allowed to lean in any direction, the reading will be inaccurate. The rod is usually held by the left hand, and the target is moved by the right hand.

The rodman should place the rod on firm ground before a reading is taken by the man operating the instrument. The rod should not be placed in a depression or on a large clod of dirt to get a reading. In freshly plowed land, the rod should be placed on a foot print that has had a man's weight on it.

When the rodman is too far from the instrument, it is necessary that hand signals be used. The following transparency shows some hand signals that may be used.

Transparency No. 4

Raise the Target - The palm of the right hand is up, and the arm is raised upward.

Lower the Target - The palm of the right hand is down, and the arm is moved downward.

Move the Rod to the Right or Left - The hand is extended in the direction the rod is to be moved. A long sweeping motion is used to indicate a long distance, while a short quick motion is used to indicate a short distance.

Plumb the Rod (Place the rod in a vertical position) - The arm is extended to full length above head and is moved slowly in the direction required as shown by the vertical cross-hair in the telescope.

Hold the Point (used to signal that the level is going to be moved) - Extend the right arm the full length above the head and wave in a circle. The rodman must not move until a backsight has been taken after the level has been set up at another point.

Rodman Has Moved the Target - The right arm is extended at a 45-degree angle from the body, and the palm of the hand is placed on the rodman's head. This signal is used by the rodman.

Observation Completed - Both arms are extended above the head and crossed.

5. Staking Out Foundations

Because constant improvements are being made in the production and marketing of agricultural products, most farmers sometime in their careers will find it necessary to remodel and enlarge existing farm buildings, build new buildings, or both. To decrease expenses, farmers will build or supervise this construction; therefore, it will be necessary that they understand how a building foundation is staked.

Transparency No. 5

Farm buildings are laid out in many sizes and shapes, but the same basic procedure is used to lay out the foundations on all buildings. Most buildings are rectangular; however, many have projections and re-entrant parts. There are separate procedures for laying out a rectangular foundation and a foundation with projections. Instructions for laying out a rectangular foundation are as follows:

1. The position of one corner (C) is determined. If the building is to be parallel to a farm road or another building, the farmer will want to measure the same distance back from the road or building in two places (NC and OP).
2. The level is set up and leveled with the point of the plumb bob over point C, as shown in the transparency.
3. The telescope is sighted at P and clamped in this position.
4. CD is measured so that it is the desired length of the building.
5. A stake is set at D in line with the vertical cross-hair of the telescope.

6. The telescope remains in the locked position after sighting at D, and the graduated circle is turned until one of its zeros coincides with the zero of the vernier.
7. The telescope is turned 90 degrees and sighted on point F. The distance from C to F is measured to get the desired width of the building.
8. The instrument is moved to D, and a stake for the E is set in manner as was F.
9. The points and measurements are checked for accuracy. The following procedure may be used:

    a. FE and CD should be measured and be the same.
    b. The instrument is moved to E, and the angles DE and EF are checked to see if they are 90 degrees.
    c. The two diagonals CE and FD should be measured. They should be equal.

Some buildings will have projections or re-entrant parts which will make them more difficult to lay out. A foundation of this type is shown in the bottom half of Transparency No. 5. The procedure for laying out the foundation of this type of building is as follows:

1. The main rectangle should be laid out first, and the smaller rectangles laid out afterward in the same manner. If one starts at one corner and continues around the building, errors will accumulate.
2. The rectangle ACIF should be laid out first.
3. The small rectangles are then laid out.
4. The points and measurements, as explained in laying out a rectangular foundation, should be checked on all rectangles or angles.

The batter boards are set up after the foundation is staked.

Transparency No. 6

The procedure to use for setting up batter boards is as follows:

1. The level is placed in a convenient location.
2. The height of the masonry is determined. The rod is held on the mark which designates the height of the masonry, and the target is set so it is bisected by the horizontal cross-hair of the level. The reading is taken and recorded. This reading will be used on all batter boards.
3. The batter boards at corner A are located. The board is raised or lowered until the target is in the cross-hair.
4. The height of the batter boards at the other corners is determined in the same manner.
5. String should be tied to the batter boards so that it will intersect directly over the four corners. The points where the string is attached to the

batter boards should be marked. A nail may be driven at this point to hold the string, or a shallow saw cut may be made to hold the string. The string is removed while the foundation is being dug. After the foundation has been dug, the batter boards should be checked to see that they are still level.

6. The line is established by setting the level over stake A, leveling it, and sighting to stake B. A plumb bob may be used at corners to see if the string intersects the point of each stake.

6. Differential Leveling

Differential leveling is used by a farmer to determine the differences in elevation at different points on his farm. The establishment of the elevation at different points is useful in running drainage lines and building soil conservation structures. These points are referred to as bench marks, after the elevation at different points has been taken and the elevation becomes permanently established.

A bench mark may be a point on a large boulder, concrete slab, or some other permanent point or spot. A bench mark can be established by driving a length of pipe (4 feet is recommended) into the ground within one-half inch of the surface. The purpose of a bench mark is to have a point with a known elevation which can be used as a reference point to determine the elevation of unknown points.

The elevation of a bench mark may be its height above sea level, if this information is known. It is customary in farm surveys to assume the elevation of the first bench mark to be 100 feet and to determine the elevation of all other points in relation to this bench mark.

Transparency No. 7

It is assumed that the elevation at BM-1 in the transparency above is 100.00 feet. The elevation at BM-2 is to be determined. The following procedure can be used:

1. The instrument is set up at some convenient distance away from BM-1 and in the direction of BM-2. The distance will depend on the accuracy of the instrument and should not exceed 350 feet. If possible the instrument should be located near the center of two readings, BM-1 and TP-1 for example.
2. A reading is taken and recorded on BM-1. This is 3.02, as shown in transparency. This reading is known as a backsight (BS), which is a reading taken on a point of known elevation. BS readings are also known as plus sights because they are added to the elevation of the last known point to give the elevation of the line of sight, called height of instrument (HI). The HI at BM-1 is 103.02 (100 + 3.02).

3. The next reading is taken at TP-1 where a temporary stake is set. The instrument is not moved to take this reading, which is called a foresight (FS) reading. A FS reading is taken at a point of unknown elevation and is called a minus sight since it is subtracted from the HI to give the elevation at the new point. The elevation or HI at TP-1 in transparency is 99.34 (103.02 - 3.68). TP-1 now has a known elevation and can be used when the instrument is moved.
4. The readings are made as explained above.

The survey should be continued until a circuit is completed, as is shown in Transparency No. 7; and the last FS is taken at BM-1. This is necessary to check the accuracy of the survey.

The final reading in most cases will not be exactly the same as the 100.00 feet which was used at the start. If there is a difference between the original reading and the last reading, this indicates an error. A reasonable allowance can be made for errors. The following formula may be used to determine a reasonable, allowable error:

> Allowable error = .014 times the square root of the length of the traverse in feet divided by 100.

There is also a "rule of thumb" that may be applied to determine allowable error: If the turning point readings are approximately 150 feet in length, the allowable error may be computed by multiplying .01 feet times the number of instrument settings.

Field notes must be kept when differential leveling. Sample field notes made from the readings in Transparency No. 7 are shown in Transparencies No. 8a and 8b.

Transparencies Nos. 8a and 8b

7. Staking Out Fence Lines

The best instrument for staking out fences is one that can be moved vertically as well as horizontally; however, a farm level may be used.

Transparency No. 9

The procedure is the same for a completely new fence line or a new fence line at a right angle to an existing fence. The following procedure may be used:

1. The instrument is set up with the plumb bob bisecting a corner stake of a completely new fence. The telescope is pointed in the direction of the

fence line, and the graduate circle is placed at zero degrees. The stakes are aligned with the vertical cross-hair. After the stakes are aligned in one fence line, one would proceed with steps 2 through 4.

If a new fence is being staked out at a right angle to an old fence, a stake in the new fence line is driven three or four feet from the existing fence. Another stake should be driven about 20 feet from the first stake and the same distance from the fence as the first stake. This stake and the stake which the plumb bob bisects are parallel to the fence. The cross-hair in the telescope should bisect the second stake. Proceed with steps 2 through 4.

2. The graduate circle is set at zero.
3. The telescope is turned until the graduate circle reads 90 degrees and points in the direction of the proposed fence line.
4. Stakes are set in the new fence line. A tape is used to measure the distance, and the telescope is used to align the stakes.

After several stakes have been set, it may be necessary to move the instrument. When the instrument is moved, it should be set over the last stake so that the plumb bob bisects the stake. A backward sight is taken on a stake, and the graduate circle is set at zero degrees. The telescope is then turned 180 degrees. The instrument is now prepared for sighting the rest of the stakes, and the same procedure may also be used to align the posts after the holes are dug.

8. Measuring Land Areas

The purpose of this discussion is to familiarize the student with procedures that can be used for measuring different shaped land areas. If land is purchased or sold and the exact quantity is not known, it is recommended that a licensed surveyor be employed.

The most common method of measuring distances is with the use of a steel tape. Measuring distances with a steel tape is referred to by many farmers as chaining. The tape is 100 feet long; and the survey lines are measured by full tape lengths, which are called stations. Distances indicated by stations provide the number of 100-foot lengths in a surveyed line. The fractional part of the distance between a full station (100 feet) is called a plus station. For example, a point 214.8 feet beyond the starting point is designated as Station 2 + 14.8, two full tape lengths plus 14.8 feet.

In order to maintain accurate measurements, it is suggested that the rules listed below be followed:

1. Keep tape on the line being measured. It may be necessary to erect tall poles between the points being measured to stay on the line. Since two

men are needed to run the chain, the second man may help the head chainman stay on the line.

2. Uniform tension should be maintained on the tape when taking each measurement.
3. The tape should be held horizontal when making measurements. In plane surveying, neglecting the curvature of the earth, all measurements on the earth's surface are considered to be on a horizontal line; therefore, to obtain accurate measurements, the tape should be held level or horizontal. It may be necessary to use a plumb bob to mark the station points accurately when the tape is held horizontal. It may be difficult to hold the tape horizontally on a steep slope. There is a method, however, that may be employed and allow the holding of the tape near the soil surface. The percent of slope must be determined between each station and a correction factor is added to the station reading.

Factors for Converting Slope Distances to Horizontal Distances

% Slope	Correction Factor	Length Along Slope to Equal 100 Feet Horizontal Distance
5	.1	100.1
6	.2	100.2
7	.2	100.2
8	.3	100.3
9	.4	100.4
10	.5	100.5
11	.6	100.6
12	.7	100.7
15	1.2	101.2
18	1.6	101.6
20	2.0	102.0
25	3.0	103.0
30	4.2	104.2

Using the above chart in an example, it is assumed that the station (one chain's length) was taken on a 15 percent slope. The correction factor for a 15 percent slope is 1.2. The 1.2 must be added to the chain's length, and the measurement would be 101.2 feet.

A hand level can be used to determine the percent of slope.

4. Either a plumb bob or correction factor must be used to mark the station point for horizontal measurements.

5. Each station should be accurately marked and accurate records kept of the number of stations.

A procedure for using the chain is outlined below. In addition to the tape, eleven pins, made of heavy wire or spikes, will be needed.

1. The two tapemen are designated as head tapeman and rear tapeman. The head tapeman carries the marking pins.
2. The head tapeman places a pin at the starting point, takes the zero end of the tape, and proceeds in the general direction of the line to be measured.
3. The rear tapeman stands at the starting point; and when the tape is pulled even with the first pin, he calls "tape."
4. At this signal, the head tapeman stops and with the assistance of the rear tapeman, who signals either to the right or left, or states "mark tape."
5. The rear tapeman holds the 100-feet mark even with the pin and calls out "right here."
6. The head tapeman pulls the tape tightly, sets the pin even with the zero mark, and calls out "right here."
7. At this signal, the rear tapeman pulls the first pin; and both tapemen advance to the next station. The same procedure is followed at 100-feet intervals.

The number of pins carried by the rear tapeman indicates the number of stations, 100-feet lengths measured. After the head tapeman has set his last pin, the rear tapeman records the number of stations (10); and delivers the pins to the head tapeman. The eleventh pin remains in the ground to mark the last point measured on the line.

If the last point measured is going to be a fractional tape length, the pin designating the last 100-feet length or station is not pulled. Mistakes are often made on the last fractional measurement. In reading this measurement, care should be taken to notice the graduations on the tape.

Measuring Angle With a Tape - It is often necessary to erect a perpendicular or right angle with respect to a line. The steel tape can be used to accomplish this. One way is to use the 3-4-5 method: A triangle is constructed with sides having multiples of 3, 4, and 5. Some desirable lengths of these multiples are 30, 40, and 50 feet and 60, 80, and 100 feet.

Transparency No. 10

Using the 3-4-5 method, a right angle is made by setting two pins 30 feet apart on the base line, AB. Then a line is marked 40 feet from point A on the base line by swinging an arc on the ground. A second arc intersecting the first arc is made on the ground by measuring 50 feet from point B.

Another method of erecting a perpendicular or angle is the chord method,

which is illustrated in the above transparency. Point A is designated on the base line and points B and C are marked equal distances from point A. In the illustration, these distances are 40 feet from point A. Then a distance greater than 40 feet (80' in illustration) is used to scribe arcs on the ground. Point D is located at the bisection of these two arcs. Line AD will then be perpendicular to the base line.

USING A STEEL TAPE TO DETERMINE AREA IN A FIELD

The use of a steel tape and the application of simple rules of mathematics can be used to determine the land area in fields and pastures. Common units of measurements which may be used are listed below:

Distance	Land Area
1 yard = 3 feet	1 acre = 43,560 sq. ft.
1 rod = 16 1/2 feet	1 acre = 4,840 sq. yds.
1 chain= 66 feet or 4 rods	1 acre = 160 rods
	1 acre = 10 sq. chains

Determining the Land Area in a Rectangle - In a rectangle, all of the angles are right angles or 90 degrees. The rule for figuring the area of a rectangle is as follows:

$$\text{Area in acres} = \frac{\text{Width in feet x Length in feet}}{43{,}560}$$

Transparencies Nos. 11a and 11b

An example is shown in illustration No. 1 in Transparency No. 11.

$$\text{Area in acres} = \frac{1240 \times 560}{43{,}560} = 15.94 \text{ acres}$$

Determining the Land Area in a Right Triangle - The area of a triangle equals one-half the product of the base and the altitude. See illustration No. 2 in the transparency.

$$\text{Area in acres} = \frac{\text{Base in feet x Altitude in feet}}{2 \times 43{,}560}$$

$$\frac{1240 \times 550}{2 \times 43{,}560} = 7.83 \text{ acres}$$

Determing the Land Area in Any Triangle - If the triangle is not a right triangle, its altitude can be located by erecting a perpendicular line on the base to the opposite corner or angle. When measurements for the base and altitude have been determined, the calculations are same as for a right triangle (ill. No. 3).

Determining the Land Area in a Trapezoid - A trapezoid is a four-sided figure with only two sides parallel. The area of a trapezoid equals the product of one-half the sum of the two parallel sides times the altitude, or the shortest distance between the two parallel sides. Illustration No. 4 in transparency is an example.

$$\text{Area in acres} = \frac{(900 + 1200) + 500}{2 \times 43{,}560} = 12 \text{ acres}$$

Determining a Land Area Having Four Non-Parallel Sides - This is accomplished by dividing the area into two triangles and determining the areas of the triangles separately. Area in acres = $\frac{\text{Base in feet} \times \text{Altitude in feet}}{2 \times 43{,}560}$

$$\text{Area No. I } \frac{1215 \times 550}{2 \times 43{,}560} = 7.67 \text{ A.}$$

$$\text{Area No. II } \frac{1325 \times 480}{2 \times 43{,}560} = 7.30 \text{ A.}$$

Total Acres 14.97

Determining the Land Area Where One Side is Straight and One Boundary is Curved - The same rules as were used for trapezoid is used. The straight side is divided into equal intervals, and perpendiculars are erected and measured at each interval. The rule states that one-half the first perpendicular (HO) plus the sum of all the intermediate perpendiculars, plus one-half the last one (HN), multiplied by the interval "D" equals the area. Since the rule assumes the irregular sides are straight lines between the intersections of the perpendiculars, the result is an approximation; however, accuracy is increased as the intervals (D in illustration No. 6) between the perpendiculars are reduced. AD = 50' is more accurate than a D = 200'.

This procedure divides the area into small trapezoids with the same "D" widths and provides a method for calculating the combined area of the trapezoids into one formula.

If one end along the base line is an odd length, take the perpendicular at the end of the last full length "D", as the end perpendicular "HN". Then calculate the remaining area of irregular width separately as a simple trapezoid or triangle and add it to the area obtained by the trapezoidal rule.

$$\text{Area in acres} = \left(\frac{ho}{2} + \text{sum } h1 \text{ to } hn + \frac{hn}{2} \right) \times d$$

$$\text{Area} = \left(\frac{178}{2} + 215 + 340 + 360 + 372 + 355 + 360 + 330 + 310 \right) \times \frac{100}{43{,}560} = 5.91 \text{ acres}$$

Determining the Land Area When all Sides are Curved - The rule for figuring the area of a trapezoid also may be used in this case. A base line is established through the area, and perpendicular offsets are measured as shown in illustration No. 7.

When the area comes to a point at each end of the base line and the end perpendiculars are zero, the trapezoid rule becomes even more simple because the half values of the end perpendiculars are omitted. The area equals the sum of all the intermediate perpendicular "H" measurements multiplied by "D".

Determining the Land Area in a Long Narrow Curved Area - The trapezoidal rule also may be used to determine the approximate land area with shapes similar to illustration No. 8. A center line, even though it is not straight, is measured, and widths (D) are measured at regular intervals. The approximate area can be determined by measuring the total length of the center line and multiplying by the average width. The width (D) does not have to be taken at any specific interval. An example of this method is provided below: Assume the center line is 2500 feet long and the width measurements were taken at 15 locations and average 43.5 feet.

$$\text{Area in acres} = \frac{2500 \times 43.5}{43{,}560} = 24.96\text{A}.$$

9. Reading Legal Descriptions

A legal description describes a piece of property in such a way that the property cannot be confused with another piece of property. The description of a particular piece of property can be acquired from a deed, title policy, public records, and an accredited survey. Several systems are used for describing property in the United States:

1. Government Survey System - This system is also called the rectangular survey system and is used by the Federal government. A rectangular area or unit of land is established 24 miles square and is bounded by base lines running east and west and meridians running north and south. This area is divided into six square-mile areas called townships. Each of the six square-mile areas are divided into 36 sections, each one mile square. The sections are numbered consecutively beginning with the section at the north-east corner of the township. This system is used by most states west and south of Ohio but is seldom used in Texas.

2. Lot and Block System - Being developed from the rectangular survey method, this system is used mostly in urban areas. When used, each block and lot is numbered and entered on a plat map of the tract.

3. Metes and Bounds System - This system is used extensively in Texas and is the oldest method of describing land. Metes are measures of length-

feet, inches, perches (1 perch = 16 1/2 ft.). Bounds are artificial and natural boundaries such as streets, roads, adjoining farms, and streams. While metes determine the quantity of land (acreage), bounds confine the quantity within certain fixed limits. A description of this type has a definitely ascertained starting point. The description proceeds clockwise and traces the lines by directions and distances back to the point of beginning.

The example given in the following transparency is a legal description of an actual piece of property in a small town in Texas, which incidentally is not named Ding Dong.

Transparency No. 12

10. Irrigation Lines and Ditches

The purpose of the information in this area is to familiarize the student with the different methods of irrigation. Hopefully, it will assist him in understanding many of the factors that must be considered in planning an irrigation system. Since the systems vary among farms and the problems in planning a system are unique to a specific farm, the planning of a system is complex and generally requires the services of an engineer.

The two principal methods of irrigation are (1) surface and (2) subsurface. Since most farms use the surface method, this discussion is confined to this method.

Transparency No. 13

There are three kinds of surface irrigation in addition to the use of sprinklers, which are discussed separately. These are (1) uncontrolled flooding, (2) controlled flooding, and (3) furrows.

Uncontrolled flooding is the releasing of water from a supply ditch onto an area that does not have levees to guide or control its flow. Areas where this system is used have a cheap and plentiful supply of water. It is difficult to apply water uniformly with this method, and it is often an inefficient means of irrigating. Size of stream, depth of water released on the area, and permeability of the soil (rate of water intake) affect the efficiency of uncontrolled flooding.

Borders, checks, corrugations, or levees are used for controlled flooding. When border strips are used, the area to be irrigated is divided into a number of strips preferably 30 to 60 feet wide and 400 to 1500 feet long. Water is turned into the strips from a supply ditch at the highest end of the strip and is allowed to flow slowly toward the lower end. The size of stream turned into each strip often varies depending upon the slope and size of strip.

Check - flooding is adapted to land that is relatively level and is suited to permeable soil that must be flooded quickly to prevent excessive water losses through deep percolation or seepage into supply ditches. It is also suited to slowly permeable soils that require the holding of water to allow for penetration of water into the soil. The levees constructed for check-flooding are 6 to 8 feet wide and 10 to 12 inches high. Higher levees prevent the crossing of equipment and may prevent the growth of the crop on the levee.

The furrow method of irrigation is often used for row crops, such as milo, cotton, and vegetables. It is suited for land having some slope. Water from supply ditches is turned into the center of the furrow at the highest end and allowed to flow to the lower end. The grade of the slope should not be so great as to cause erosion.

Sprinkler systems are a very popular means of irrigating crops. The use of sprinklers usually does not require the construction of ditches or water retaining structures. Numerous kinds are manufactured, and some systems are more suited for certain conditions.

The Use of the Level and Tripod in Laying Out Irrigation Structures - The level and target rod are used to lay out water supply ditches. In order for the supply ditch to provide a constant supply of water at an adequate level along the length of the ditch, the ditch must usually be sloped. The amount of slope will vary depending upon the size of the ditch, the source of water, and whether the ditch is lined or not.

It is a fairly simple matter to provide adequate slope when laying out the ditch with a tripod and level. Assuming that one inch of slope is required for each 100 feet, the following procedure may be followed in laying out the ditch:

1. Determine the highest point in the ditch channel and record the reading on the target rod. An ideal situation would be for the highest point to be at one end of the ditch, but this is not always possible. The highest point may be near the center of the length of the ditch. If this is the case, water will have to be directed in two directions; but the same procedure would be followed.

2. Add one inch to the highest point reading and place the target on this reading.

3. Walk 100 feet from the first reading, and move the rod up or down hill until the cross-hairs in the level match the cross on the target.

4. Add one inch to the second reading and move the target to this reading. This will be the reading for the third 100-foot station. One inch is added for each 100 feet until the ditch has been laid out.

Contour levees are sometimes used to control water in strips. These may be laid out on the level, or given some slope. If the contours are laid out on the level, the same reading on the target is used for each 100-foot station. If slope is provided for the levee layout, the same procedure is followed as was used for laying out ditches.

Credit is given to Vocational Agriculture Service, University of Illinois, Urbana, Illinois for much of the information contained in this topic.

References:

1. "Farm Surveying", Vocational Agriculture Service, University of Illinois, Urbana, Illinois, 1970.

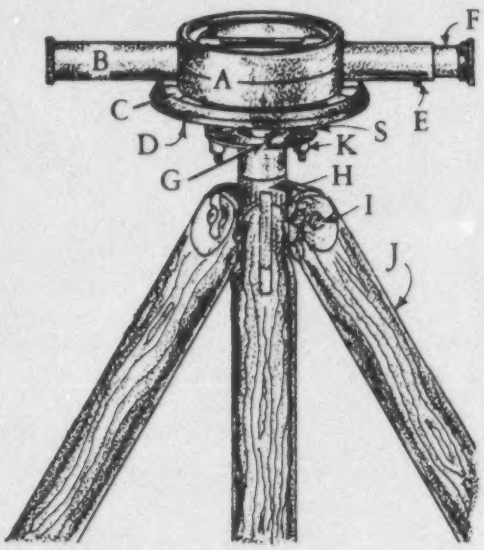
2. Ayres, Quincy C. Land Drainage and Reclamation, McGraw-Hill Book Company, Inc., New York, New York.

3. "The Farm Level", Kansas State College, Manhattan, Kansas.

4. "Planning for An Irrigation System", The American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1971.

5. Jacobs, Clinton O. and Mattox, Keith E., Leveling and Land Measurement Practices for Agriculture, Department of Agricultural Education, University of Arizona, Tucson, 1974.

PARTS OF FARM LEVELS

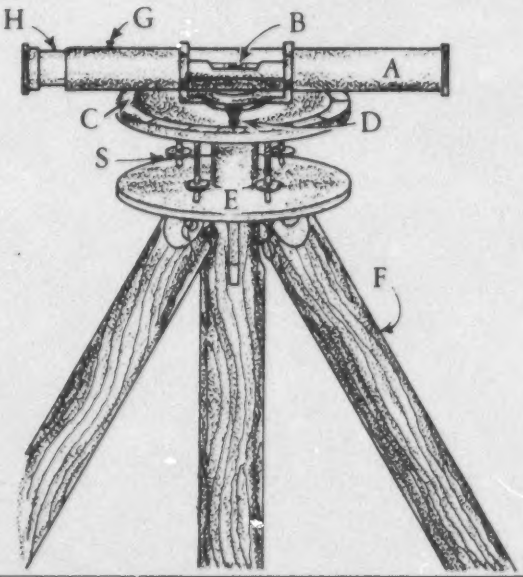


TURRET TYPE

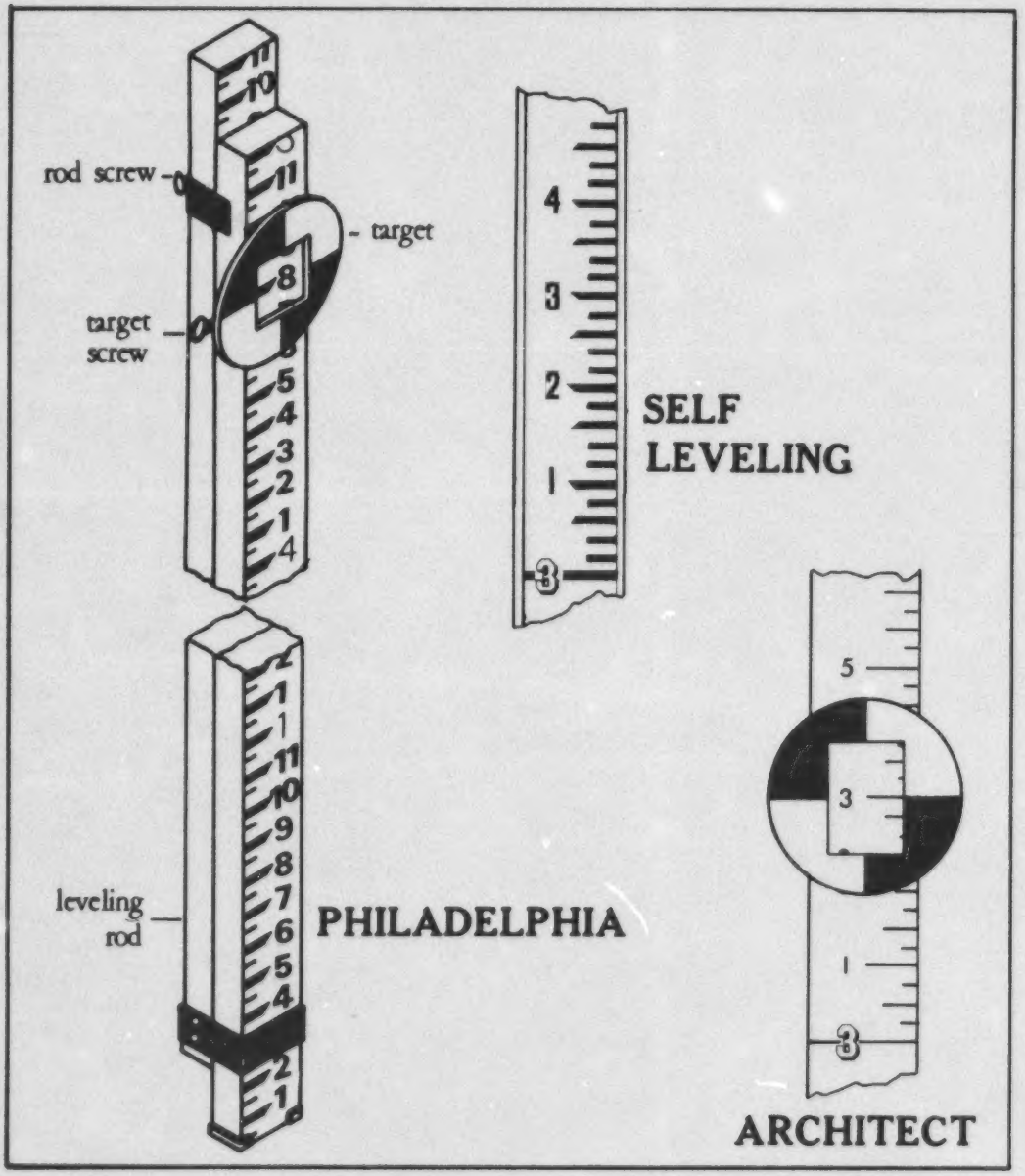
A - TURRET
B - TELESCOPE TUBE
C - GRADUATED CIRCLE
D - LEVELING PLATE
E - SLIDE SCREW
F - SLIDE TUBE
G - LEVELING HEAD
H - TRIPOD HEAD
I - LEG BOLTS
J - TRIPOD LEGS
K - BOSS
S - LEVELING SCREWS

UTILITY TYPE

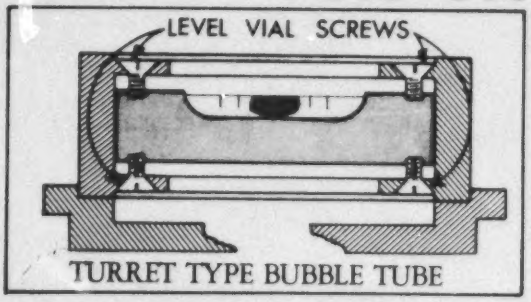
A - TELESCOPE
B - LEVEL TUBE
C - GRADUATED CIRCLE
D - INDEX ARM
E - BASE PLATE
F - TRIPOD LEGS
G - SLIDE SCREW
H - SLIDE TUBE
S - LEVELING SCREWS



TARGET RODS

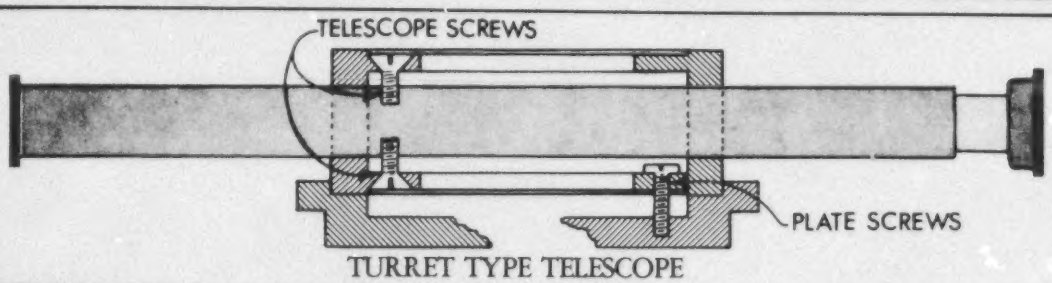

rod screw
target
target screw
leveling rod
PHILADELPHIA
SELF LEVELING
ARCHITECT

BUBBLE TUBE, TELESCOPE, AND CROSS HAIR

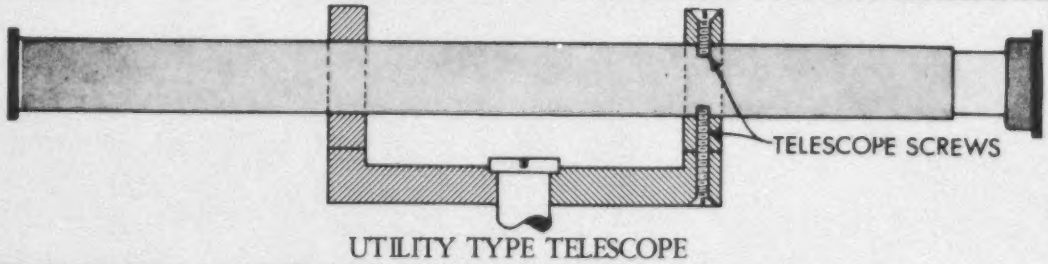


TURRET TYPE BUBBLE TUBE

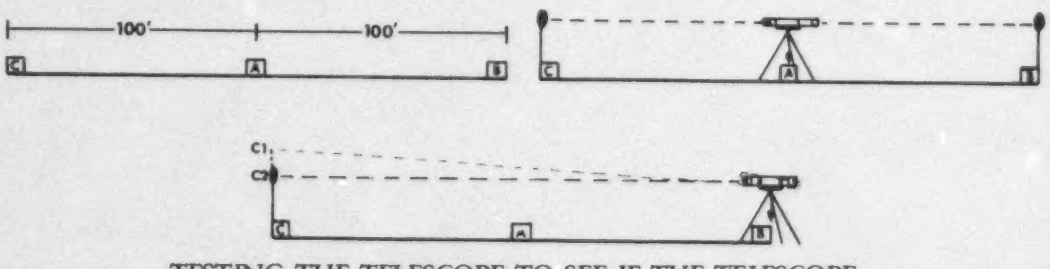
UTILITY TYPE BUBBLE TUBE



TURRET TYPE TELESCOPE

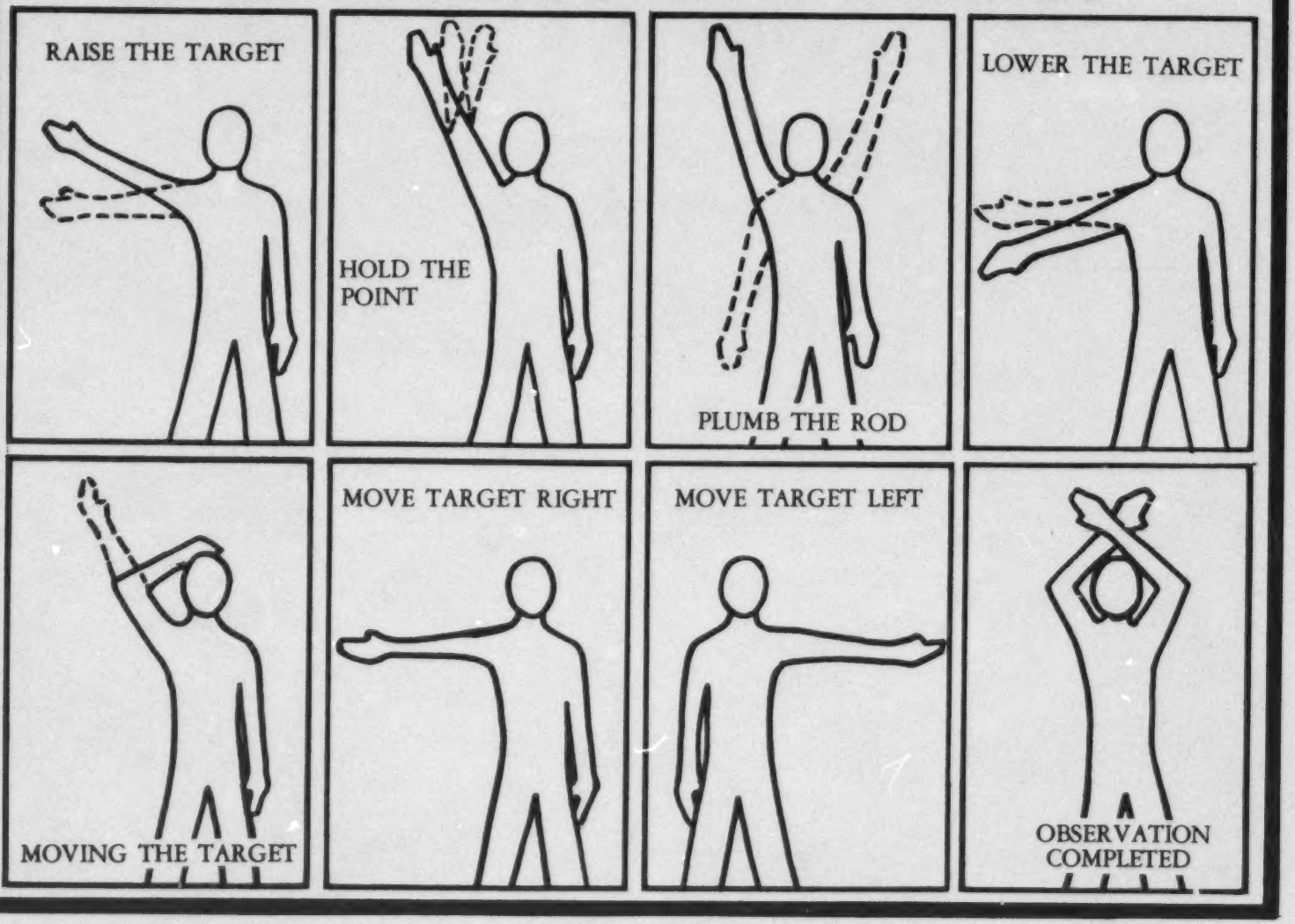


UTILITY TYPE TELESCOPE

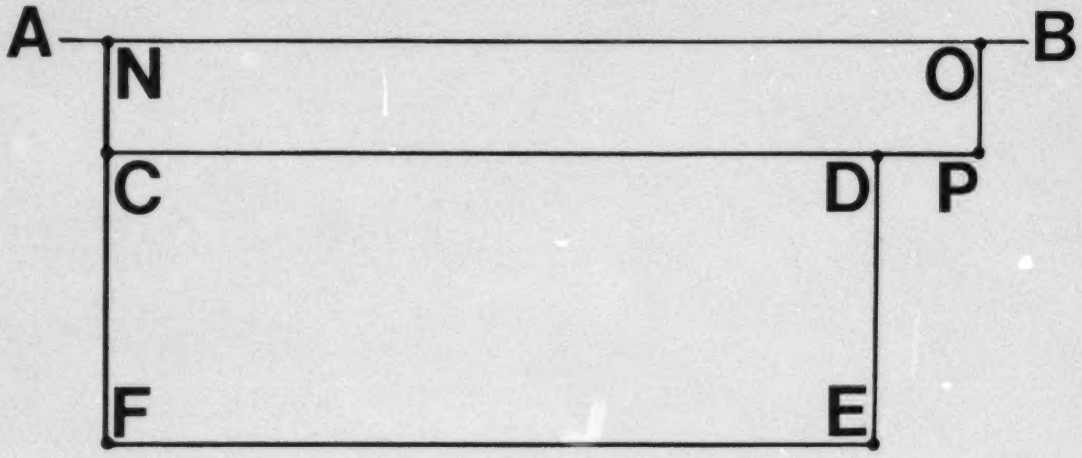


TESTING THE TELESCOPE TO SEE IF THE TELESCOPE IS IN THE LINE OF SIGHT OF THE LEVEL

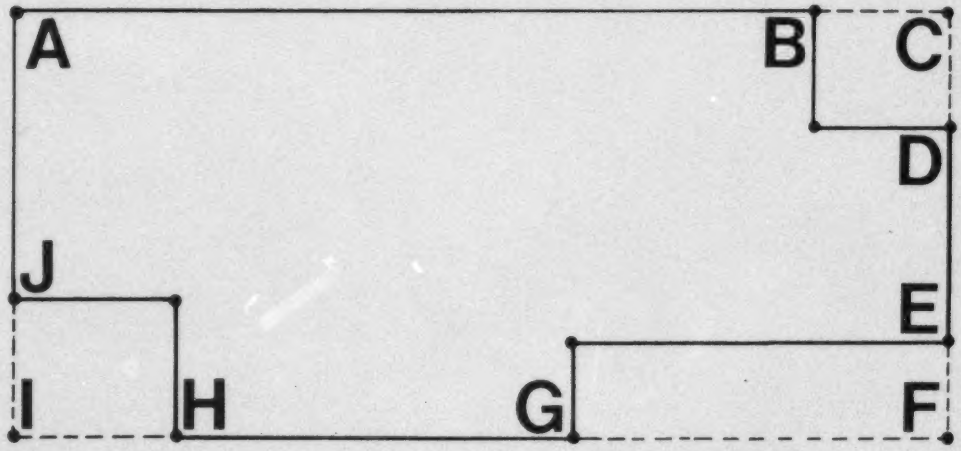
ROD HOLDER'S HAND SIGNALS



STAKING OUT A BUILDING FOUNDATION

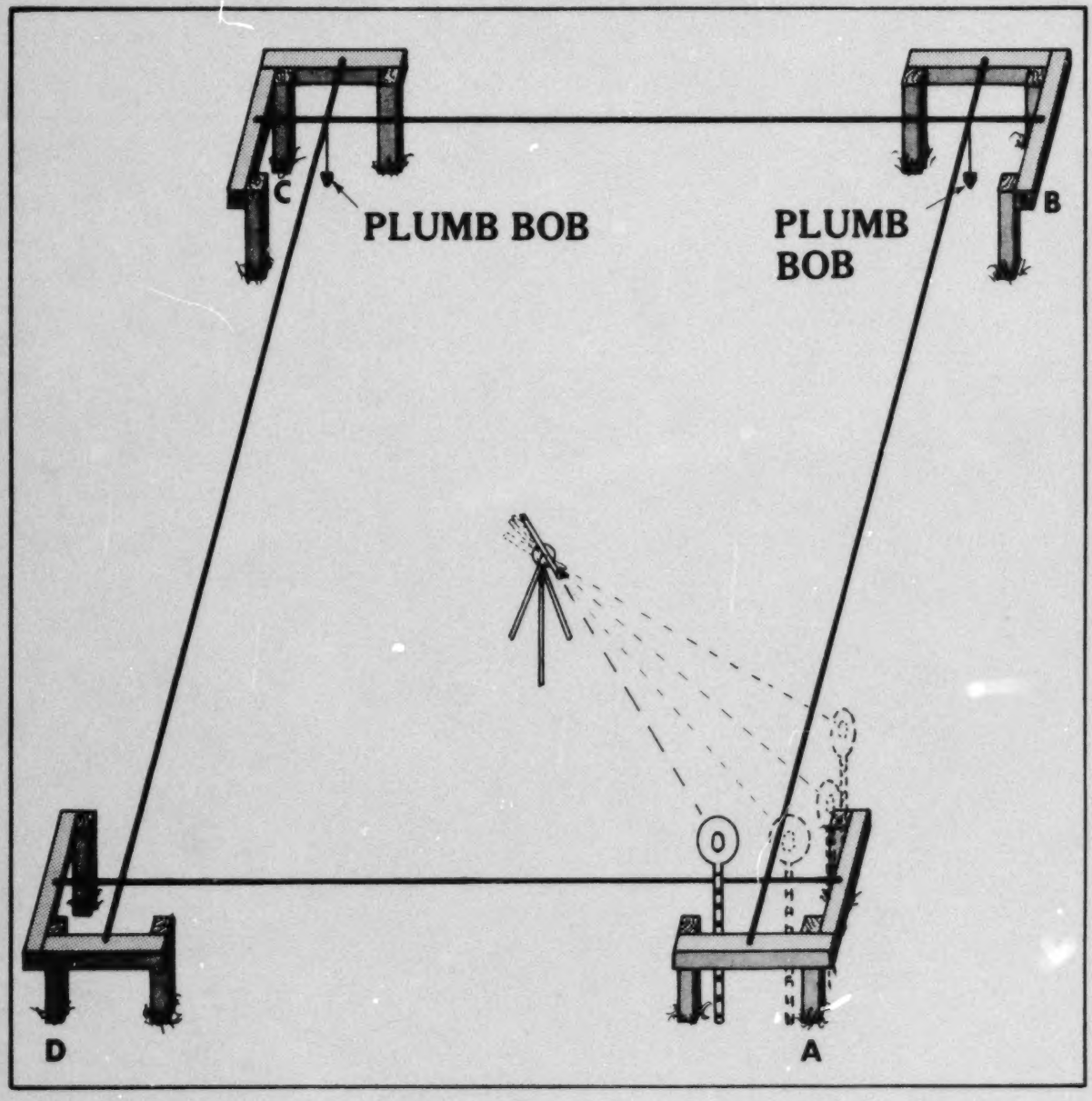


A RECTANGULAR BUILDING

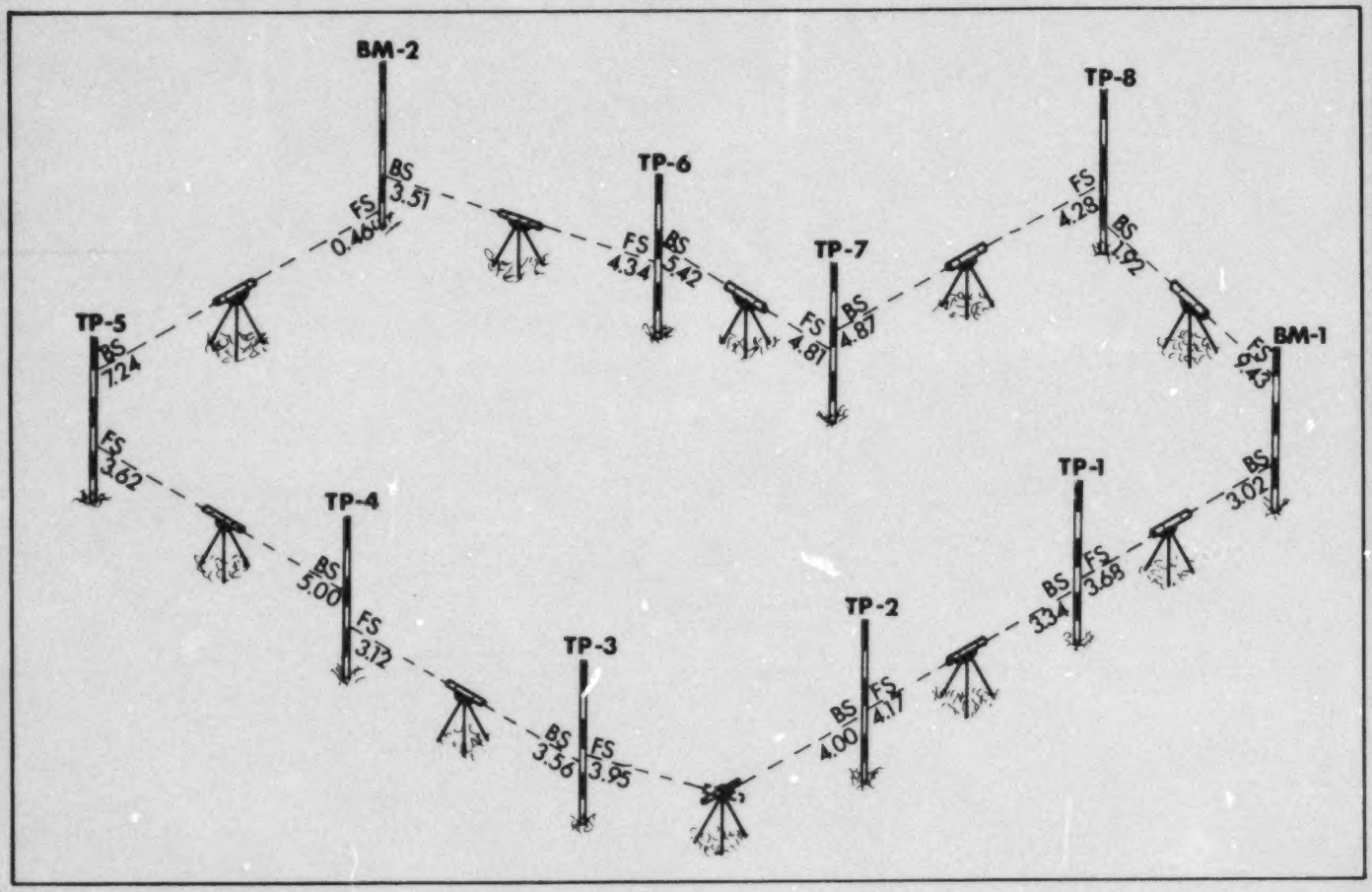


A BUILDING WITH PROJECTIONS OR RE-ENTRANT PARTS

SETTING UP THE BATTER BOARDS



AN EXAMPLE OF DIFFERENTIAL LEVELING

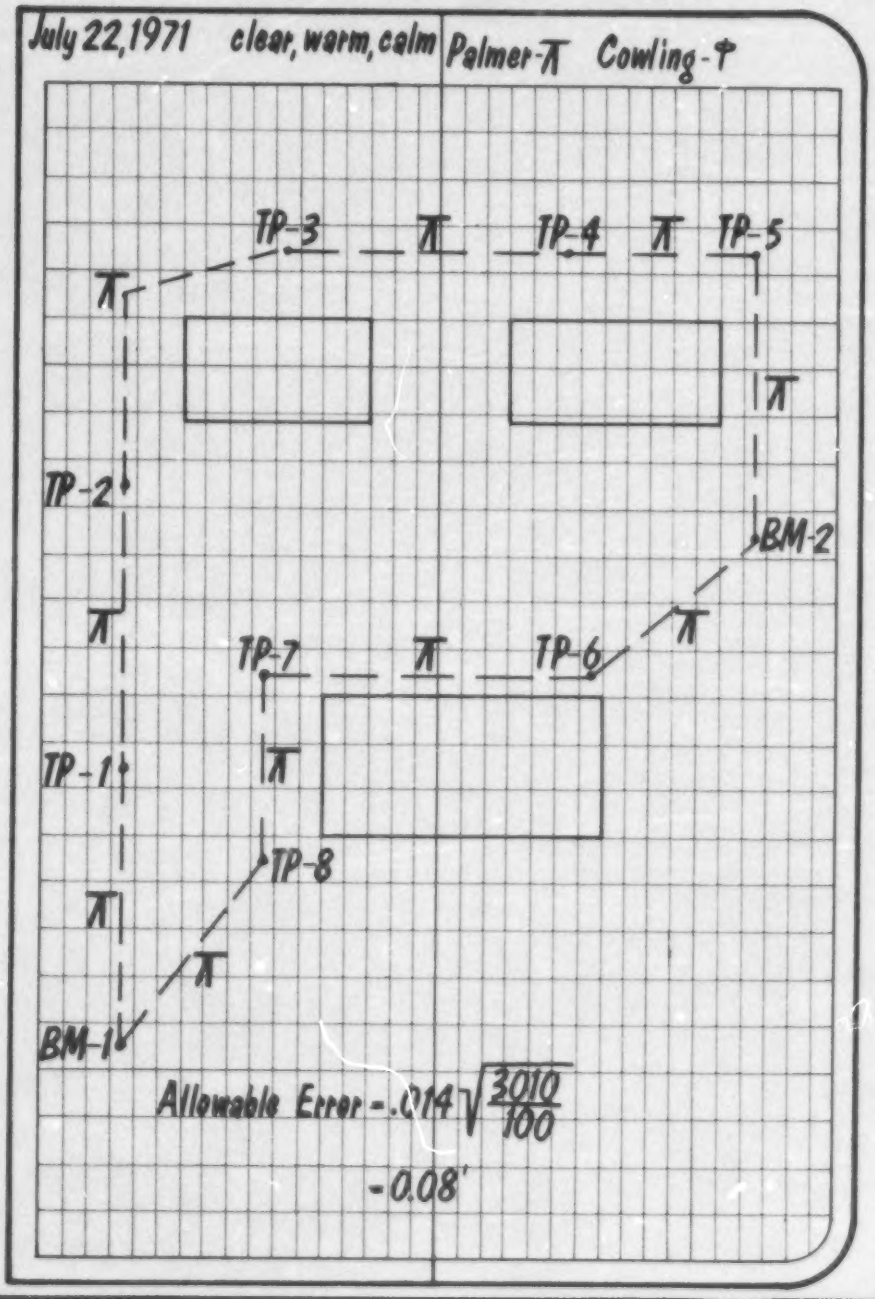


DIFFERENTIAL LEVELING FIELD NOTES

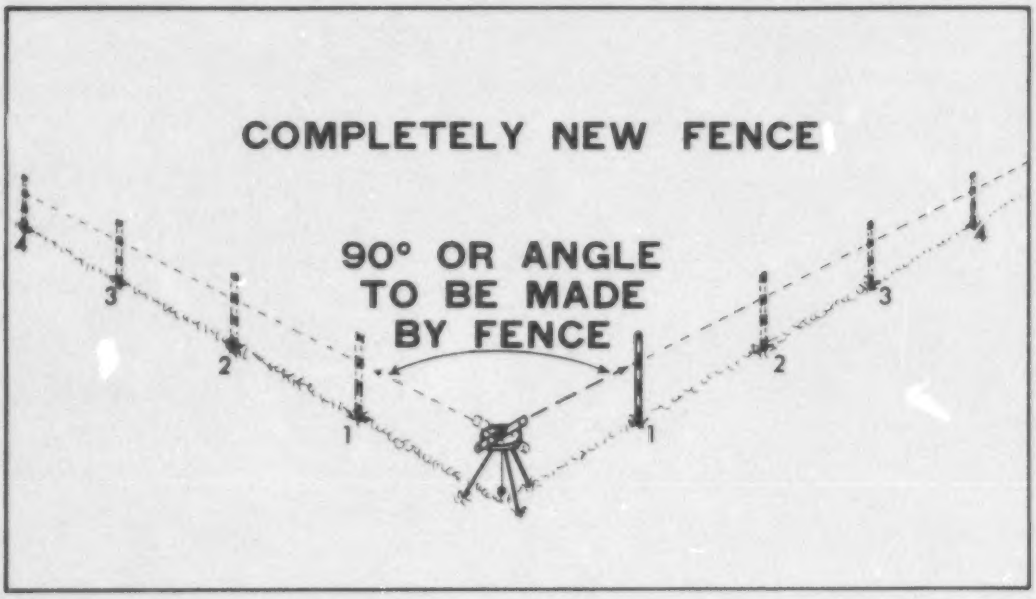
Differential Leveling

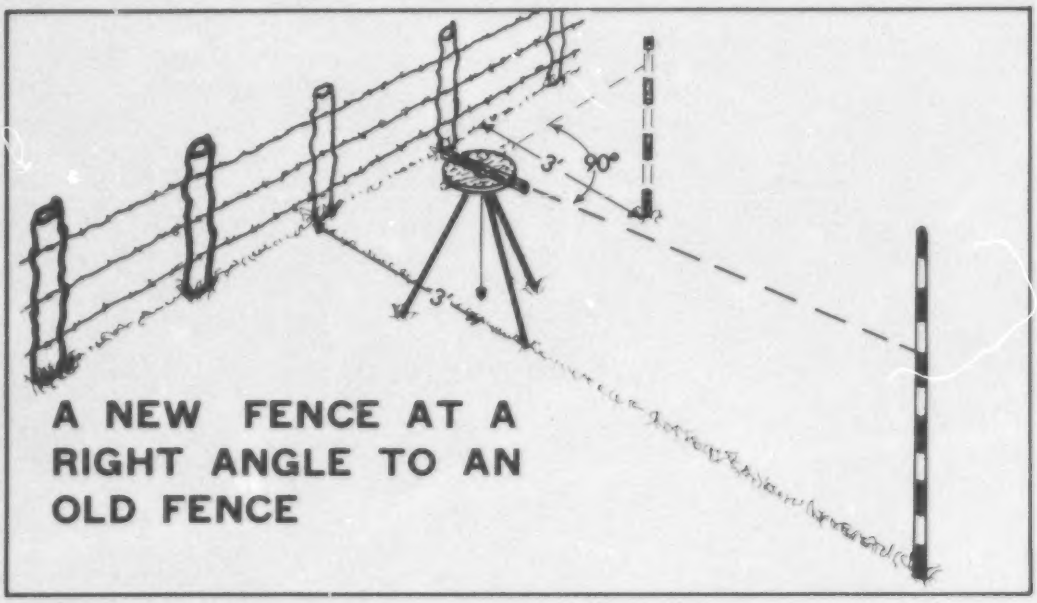
Sta.	BS	HI	FS	Elev.	Dist.
BM-1	3.02			100.00	
		103.02			250
TP-1	3.34		3.68	99.34	
		102.68			270
TP-2	4.00		4.17	98.51	
		102.51			330
TP-3	3.56		3.95	98.56	
		102.12			300
TP-4	5.00		3.12	99.00	
		104.00			320
TP-5	7.24		3.62	100.38	
		107.62			370
BM-2	3.51		0.46	107.16	
		110.67			320
TP-6	5.42		4.34	106.33	
		111.75			280
TP-7	4.87		4.81	106.94	
		111.81			310
TP-8	1.92		4.28	107.53	
		109.45			260
BM-1			9.43	100.02	
					3010
		Error -	0.02'		

DIFFERENTIAL LEVELING FIELD NOTES (Cont.)



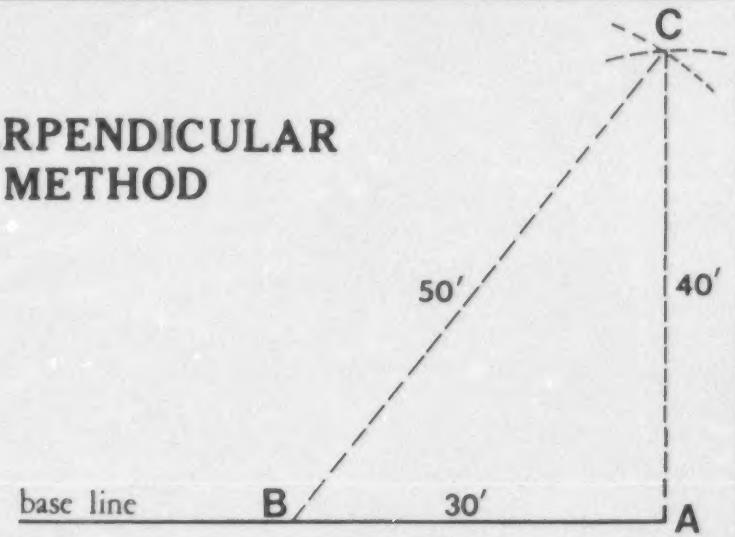
STAKING OUT FENCE LINES



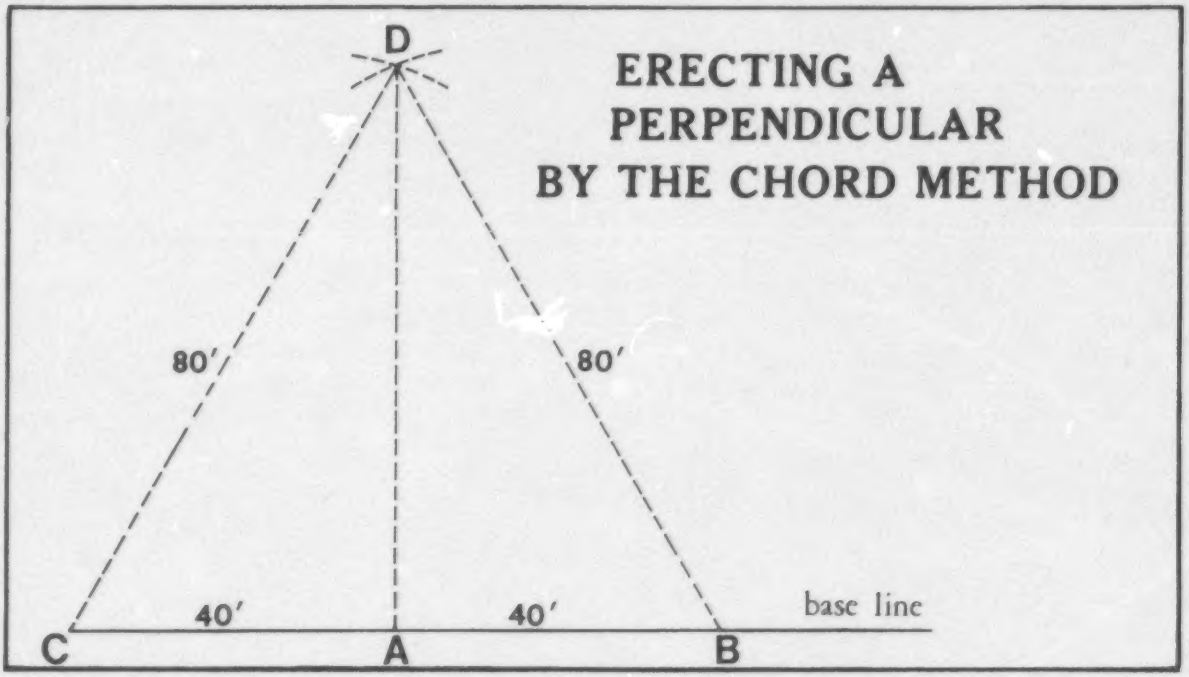


MEASURING ANGLES WITH A STEEL TAPE

ERECTING A PERPENDICULAR BY THE 3-4-5 METHOD



ERECTING A PERPENDICULAR BY THE CHORD METHOD



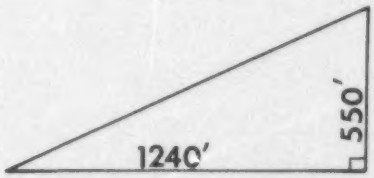
DETERMINING LAND AREAS

1

RECTANGLE

$$\frac{1240 \times 560}{43{,}560} = 15.94 \text{ ACRES}$$

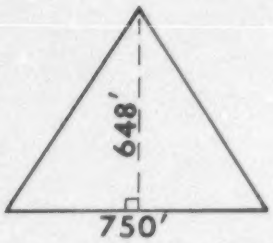
2



RIGHT TRIANGLE

$$\frac{1240 \times 550}{2 \times 43{,}560} = 7.83 \text{ ACRES}$$

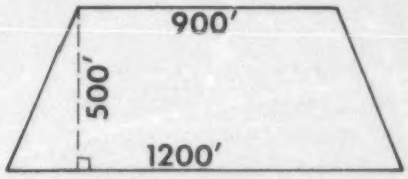
3



ANY TRIANGLE

$$\frac{750 \times 648}{2 \times 43{,}560} = 5.57 \text{ ACRES}$$

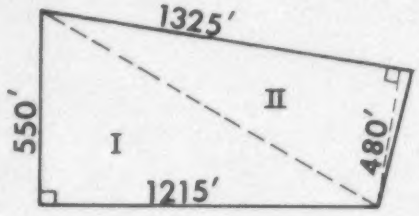
4



TRAPEZOID

$$\frac{(900 + 1200') \times 500}{2 \times 43{,}560} = 12 \text{ ACRES}$$

5



FOUR-SIDED AREA, NON-PARALLEL SIDES

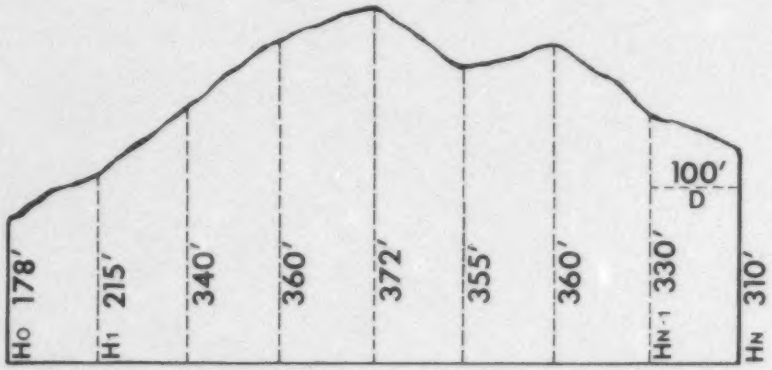
AREA I IN ACRES → $\frac{1215 \times 550}{2 \times 43{,}560} = 7.67$

AREA II IN ACRES → $\frac{1325 \times 480}{2 \times 43{,}560} = 7.30$

TOTAL ACRES 14.97

DETERMINATING LAND AREAS

6

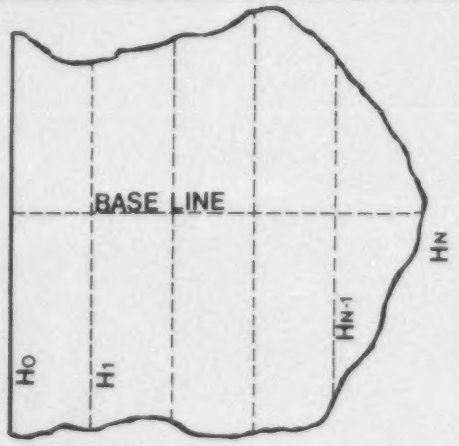


ONE STRAIGHT SIDE, ONE CURVED BOUNDARY

$$\text{AREA} = \left(\frac{H_O}{2} + \text{SUM } H_1 \text{ TO } H_{N-1} + \frac{H_N}{2}\right) \times D$$

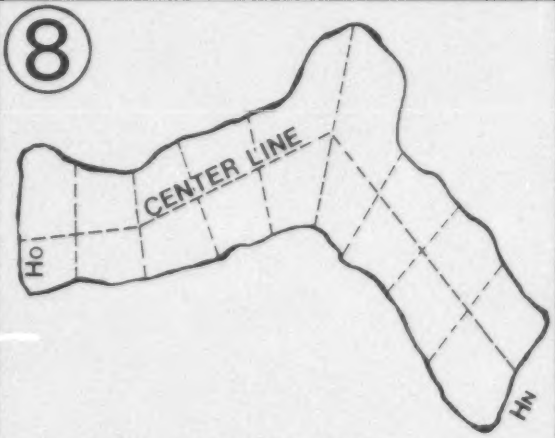
$$\text{AREA} = \left(\frac{178}{2} + 215 + 340 + 360 \quad 372 + 355 \quad 360 + 330 + \frac{310}{2}\right) \times \frac{100}{43{,}560} = 5.91 \text{ ACRES}$$

7



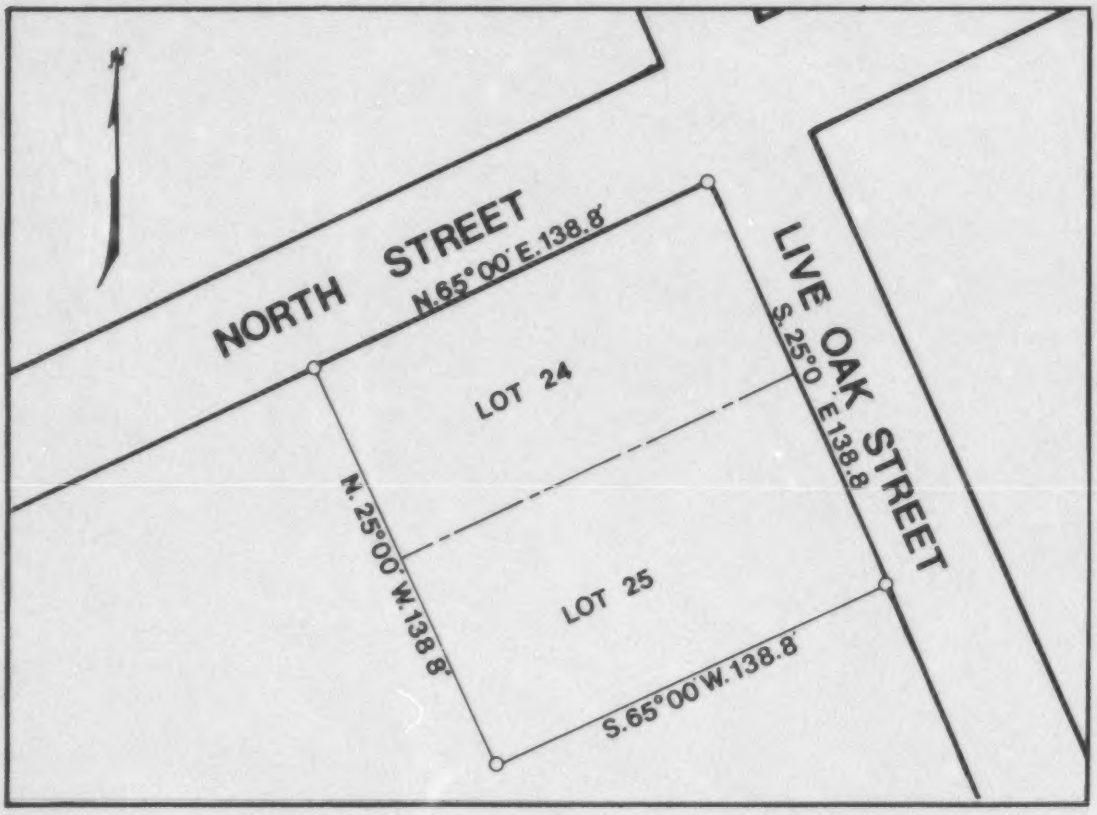
AREA WITH BOTH SIDES CURVED

8



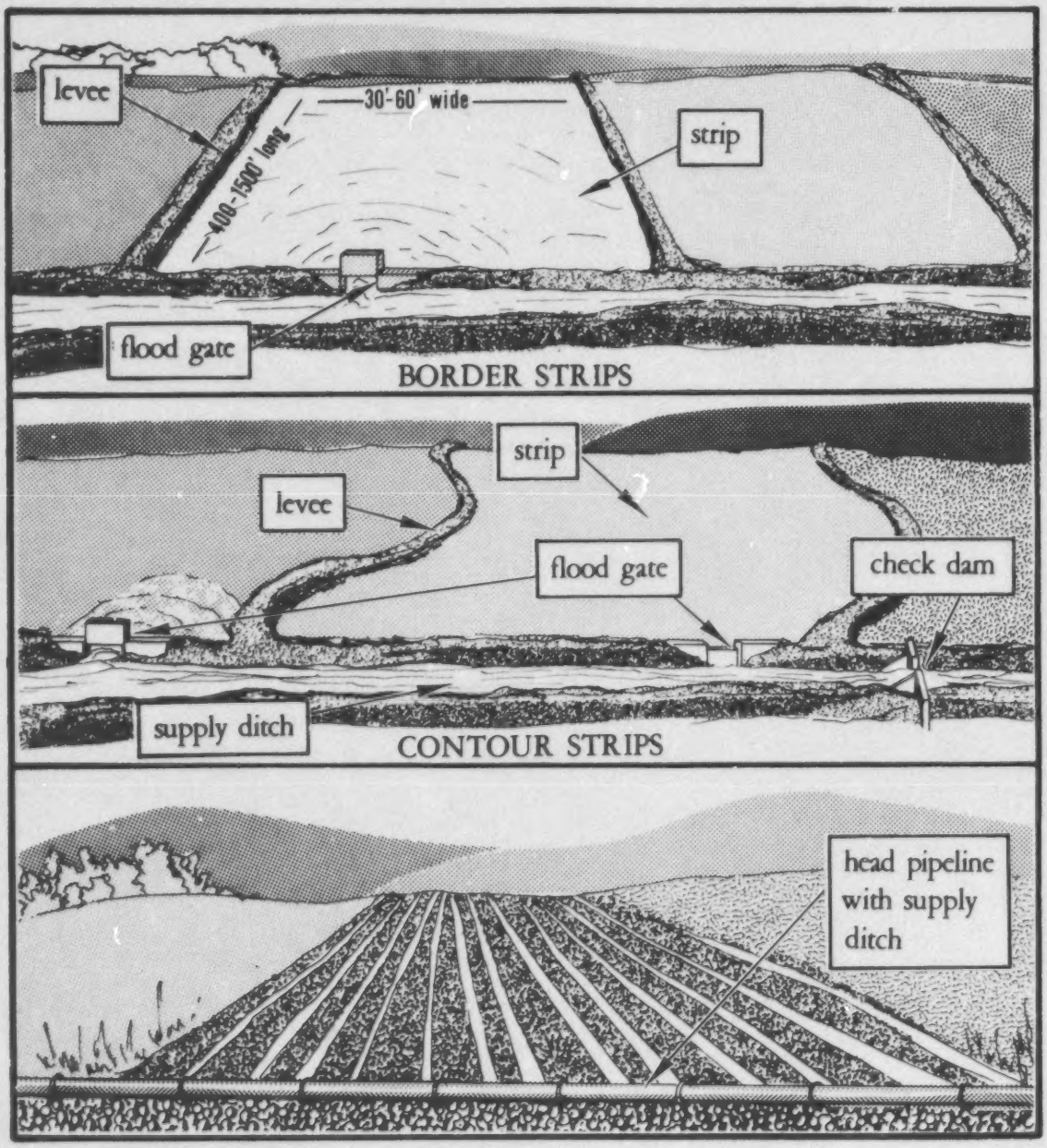
LONG, NARROW, CURVED AREA

DESCRIPTION BY METES AND BOUNDS



A DESCRIPTION OF TWO LOTS BY METES AND BOUNDS: BEGINNING AT AN IRON PIPE SET FOR THE S. W. CORNER OF THE INTERSECTION OF LIVE OAK STREET AND NORTH STREET IN DING DONG, TEXAS, BEING THE N. CORNER OF SAID LOT NO. 24; THENCE WITH THE W. LINE OF LIVE OAK ST. S. 25 DEGREES E. 138.8 FEET TO PIPE SET FOR THE E. CORNER OF SAID LOT 25; THENCE S. 65 DEGREES W. 138.8 FEET TO PIPE SET FOR THE S. CORNER OF SAME LOT 25; THENCE N. 25 DEGREES W. 138.8 FEET WITH THE S. W. END OF LOTS 25 AND 24 TO AN IRON PIPE SET FOR CORNER IN THE S. LINE OF NORTH STREET; THENCE WITH THE SAID S. LINE OF NORTH STREET N. 65 DEGREES E. 138.8 FEET TO THE PLACE OF BEGINNING.

SURFACE IRRIGATION



CONSTRUCTION AND MAINTENANCE

Unit B: Farm Carpentry

Topic 1: Planning and Constructing Buildings and Equipment

Note: Several options are available to the farmer who plans to build a farm structure. Blueprints and the bill of materials may be prepared by an architect, a carpenter, contractor, or the farmer. The building of a structure may be contracted, or certain parts of the structure may be subcontracted, or the entire structure may be built by the farmer.

The information in this topic is directed to the owner-builder, who will prepare the plans, figure the bill of materials, and construct the structure.

1. Building and Equipment Plans

Detailed plans and blueprints are very important, for they determine the cost, affect the quality of work, and save time. Considerable time and effort must be expended in the planning of a structure if it is going to meet the needs for which it was intended. Because of the rapid changes in cultural and production methods, immediate as well as long-term needs must be considered. Since it is difficult to anticipate future uses and needs, many farmers construct utility buildings, which can be remodeled with a minimum of change to the structure.

Using the following steps should be helpful in making the plans and determining the size of structure to build:

a. Prepare a list of present and future uses of the structure. Immediate needs should be given precedence over probable long-term needs. The builder may wish to plan the structure so that an addition can be constructed to meet future needs.
b. The amount of floor space required for each use is determined. Some uses might be the storage of crops, equipment, vehicles; protection for animals; and a farm shop.
c. A list of the equipment to be used in the structure is compiled. Space must be provided for equipment. Also, passage space around equipment must be considered when determining the size of the structure.
d. Total floor space needs are determined.
e. Review plans and blueprints of several different types and kinds of structures used for similar purposes. The builder may wish to observe some of the better farm buildings in the area in which he lives.

f. The type of construction is determined. A discussion of the types of construction is included in this topic.
g. Prepare or secure a detailed blueprint and accurate bill of materials.
h. Select a building site. Convenience is of primary importance in selecting a site. A study of the farm vehicle traffic pattern may be helpful. The utilities that will be needed at the site should also be considered.

2. Roof Types

There are many different roof types, building materials, and construction procedures that may be used in building farm structures. Some of the factors to consider in making decisions related to these items are discussed.

Transparency No. 1

Some of the roof types used on farm structures are shown in the above transparency. The shed and gable roofs are the most common. The shed roof usually is entered from one side, the side having the most clearance; therefore, this type of roof is generally not used for a building where equipment will be driven through the building.

Unless doors are installed on the front, equipment and other stored items may not be protected from blowing rain and snow. If the building is to be free of center posts and have a wide span, another type of roof should be used. The maximum recommended distance between posts or studs on a shed roof is 18 feet.

Longer spans will not provide the strength needed for the roof to withstand wind pressure or snow.

Buildings having gable roofs may be entered from the sides and/or ends and are particularly adapted for through vehicle traffic. Extremely tall equipment may enter at the ends of a gable roof building, if the rafters or trusses have been constructed to provide the needed height. If rafters are used, the recommended span of a gable roof is 24 feet, while the building may be as much as 60 feet wide if trusses are used.

The half-and full-arch are two other roof types. The roof framing is constructed of prefabricated or laminated beams. The half-arch is generally entered from the side, while the full-arch must be entered from the end. The span on a half-arch roof is limited to about 25 feet.

An umbrella roof is used to store items and protects them from direct rainfall and snow.

The gambrel roof was more popular in the 1930s. It allowed more space for

storage in the upper part of the structure and was used by many farms for the storage of hay.

Rigid steel frames are available with post free spans of 70 feet or more. These are tested by the manufacturer for stress and will stand wind pressure if constructed according to the manufacturer's specifications. The use of this type of roof support is increasing in popularity.

Regardless of the type used, the roof frames must be strong enough to withstand wind pressure, the weight of snow, and to support the roof. The size and spacing of rafters, trusses, and steel frames are determined by the amount of wind pressure expected, weight of roofing materials, length of rafters, and dimension of lumber used for the roof framing. The dimensions of lumber have the greatest influence on the strength of the roof.

For example, a 2" x 8" is four times as strong as a 2" x 4" and twice as strong as a 4" x 4". The grade of lumber also affects its strength.

3. Roof Framing

Transparency No. 2

Along with determining the type of roof to use, the builder must be familiar with the types of roof framing. Attention is called to the maximum recommended widths for each type of framing. Some manufactured frames are shown in the following transparency.

4. Construction Practices

Transparency No. 3

The most critical areas in a structure affecting its strength are (a) where rafters or trusses join the plate, side walls, or columns; (b) where poles rest on piers; (c) where the sill rests on the foundation; and (4) where rafters are joined at the roof ridge. The practices or methods used in joining the different parts of a building are very important, as they affect its length of useful life.

5. Foundations and Wall Supports

Different kinds of foundations and the ways foundations are joined to other structural parts are shown in the following transparency.

Transparency No. 4

Poles are often used for the foundations of utility buildings; and they make good foundations if they are placed at the proper depth, are backfilled prop-

erly, and the roof is well-anchored to the poles. Eight inches of concrete or one foot of gravel should be placed in the bottoms of the holes to prevent the poles from sinking deeper into the soil.

The length of the poles to be used and the method used to set the poles will determine the depth of the holes. Usually the hole depth will vary from four to six feet. Holes in soft soils should be dug at the greater depth. A rule of thumb for hole depth is four feet for poles 16 feet or less in length and a hole depth of five to six feet for poles 16 to 25 feet long. Shallower holes may be used if the poles are encased in concrete. Metal poles having bearing plates resist overturning and uplifting much better than wooden poles, and may be set at a shallower depth.

If concrete footing is used for the foundation, it should be twice as wide as the pier or masonry blocks which rest upon it. The thickness of the footing should also be twice the thickness of the foundation wall. For example, the footing for a ten-inch thick foundation wall should be 20 inches thick. The above recommendations must be followed if the foundation is to resist settling due to the weight of the building; soil movement caused by moisture changes, freezing, and thawing; and the uplift and overturning force of wind.

6. Anchoring Roof Framing to Poles and Wood Frames

Transparency No. 5

The method used to anchor the roof to the poles affects the strength of the building, and the method to use will depend upon the size of the building. An illustration of one method of fastening rafters to joists is shown. There are other equally as satisfactory methods.

The size of wood framing materials to use for walls depends upon the amount of weight the wall is expected to carry. A side load (wall storage area), or an overhead load, such as a hoist, will require the use of larger dimensioned studs or poles. The kind and amount of wall bracing used also affects the size of lumber to use.

7. Selecting Roofing Materials

Cost, life expectancy, resistance to hail and fire, slope of roof, and resistance to wind and sun are factors to consider in selecting roofing materials.

Transparency No. 6

Sheets of asbestos - cement have a long life expectancy and are resistant to the elements of nature; however, they are easily damaged by a heavy impact, such as a rock. They are also heavier than most other kinds of roofing materials.

Galvanized steel and aluminum sheets are the most popular roofing materials for farm structures. They have a long life expectancy, are resistant to the elements of nature, and are fire proof. However, the builder is reminded that the gauge and coating of zinc affect life expectancy of galvanized steel. The minimum recommended gauge of galvanized steel is 29 with at least two ounces of zinc coating. The minimum aluminum gauge recommendation is .0215. Aluminum sheets must be well-secured (nailed or other means of fastening) to resist wind.

Wood shingles do not last as long as galvanized steel, aluminum, or abestos-cement shingles; and they readily burn.

Asphalt shingles are more expensive because they must be put over solid decking; and after becoming heated, they will burn. The life expectancy of asphalt shingles is shorter than steel, aluminum, and asbestos-cement shingles.

Both types of asphalt rolled roofing are similar in all aspects to asphalt shingles.

8. Figuring Material Costs

Since most builders must have a fairly accurate estimate of the cost of a structure before it is built, the cost of a structure is very important to its construction. The cost should be determined before the plans are completely finalized to allow for the substitution of materials and possible plan changes to reduce cost, if it is necessary.

The first step in estimating building cost is to review the blueprint and determine the areas of the structure that are similar in construction and require similar materials. Structures usually have parts that form a square, rectangle, or triangle. Areas that are similar are designated on the blueprint by numerals or letters. The bill of materials is figured for one area and is multiplied by the number of areas that are similar.

Building materials such as lumber, siding, and roofing are calculated by area. Height x length = area. A sample bill of materials is figured below.

Transparency No. 7

The example in the above transparency is of a rectangular building which has several areas requiring the same amount of materials. These are designated in the illustrations as A, D, E, and F. The materials required for one area are determined and multiplied by two to determine the amount and cost of materials for both areas. Side C in the example is open. It is assumed that 2" x 6" lumber will be used for studs, rafters, and braces and galvanized sheet

iron or aluminum will be used for siding and roofing. Studs are placed two feet apart, and two studs are used at each corner.

9. Bill of Materials for One "A" Wall

18 pieces of 2" x 6" x 12' are needed for one "A" wall. Both "A" walls will require 36 pieces for studs.

5 pieces of 2" x 6" x 12' are required for the sill for one "A" wall. 9 pieces will be required for both "A" walls. (One "A" wall only requires about 2 feet of one of the 2" x 6s" used for the sill.)

If the 2" x 6s" are doubled at the plate, 9 pieces of 2" x 6s" are required for the plate in one "A" wall. Both "A" walls will require 18 pieces. (There will be some waste in this area.)

The siding required for the "A" walls is determined as follows:

One "A" wall dimension -12' x 30' = 360 sq. ft.

$$\begin{array}{rl} & \times\ 2 \\ \hline \text{Area in both "A" walls} - & 720 \text{ sq. ft.} \end{array}$$

Sheet iron or aluminum, as previously stated, will be used for siding. Siding is sold by the square. A square is 100 sq. feet, or a 10 ft. by 10 ft. area. The most commonly used sheets are 26 inches wide; however, wider sheets are available. The 26-inch sheet allows a two-inch lap or joint where sheets are joined. Therefore, a 26-inch sheet actually covers 24 inches of wall space. A 26" x 12' sheet of galvanized sheet iron would cover 26 square feet of space if it was not lapped; but because of the lap, the sheet only covers 24 square feet of siding space. To cover 360 square feet of wall space, 3.9 squares or 15 sheets of 26" x 12' galvanized iron are required. Twice as much is required to cover both of the "A" walls.

The materials used in the other areas of a structure are calculated in the same manner.

A fairly accurate estimate can be made of the cost of a structure by determining the number of square feet in the building and multiplying this by the cost per square foot for similar structure. After a builder has had some experience in building and figuring bills of materials, he can make a rather accurate cost estimate. This is a popular method for experienced builders. Open and/or unfinished areas, such as sheds, are calculated on a different basis than completely enclosed areas.

Another method used to calculate building cost is to use cubic feet. This method is used to determine the volume of buildings beyond the average one-story height. Volume is determined by multiplying the length x width

x height. Dimensions used are six inches below the floor to the top of the roof for building with flat roofs. On a pitch roof, the top measurement is taken at a point one-half the gable height (b+½a). The cost of the structure is divided by the total volume to find the cost per cubic foot.

10. Laying Out Rafters and Trusses

Prior to beginning the study on rafters, the student should become familiar with the parts of the square and the tables on the square. The tables are discussed in detail in the student materials, "Measuring and Marking Devices," and provide the information needed to determine the length and cuts of rafters.

The student should also know the terms used for the different parts of rafters and building parts joined to rafters and trusses.

Transparency No. 8

Plumb cut - This is vertical cut at the top end of a rafter, at the seat cut, and may be the cut at the tail end. The plumb cut at the ridge is referred to as the top plumb cut, while the plumb cut at the tail is referred to as the bottom plumb cut.

Seat cut or bird's mouth - The seat cut rests on the plate. The square is used to make the correct angle and depth of cut. The depth of cut should usually be no more than one-half the width of the lumber used for the rafters.

Plate - The top part of the wall on which the seat cut rests.

Ridge - This is the top of the roof or highest framing member where two rafters are joined. A ridge board is sometimes used between the rafters to strengthen the framing members. A ridge board also aids in aligning the roof and tying the roof members together.

Span - This is the distance from one outer plate edge to the outer plate edge of the opposite wall. It is the width of the building.

Run - The distance from the edge of one outer plate to the center of the building.

Rise - The vertical distance from the top of the plate to the ridge. Several methods may be used to find the rise of a building: (1) Multiply pitch x span; (2) Rise per foot of run is determined by multiplying pitch by 24; and (3) Divide rise by span and multiply by 24.

Pitch - The slope of the roof, or the number of inches of rise per foot of run. Pitch is usually expressed as a fraction, such as 1/3, 1/4, 1/6, etc.

Transparency No. 9

Rafters are laid out (stepped-off) with a carpenter square. The square forms a right angle and is composed of two parts, the blade (24 inches long) and the tongue (16 inches long). The numerals on the tongue of the square are used to designate the rise, while the blade is used to designate the run. The pitch and the kind of rafters being cut determine the numerals used on the tongue and blade of the square.

NUMERALS USED FOR DIFFERENT PITCHES
Common Rafters

Pitch	Run	Rise
1/12	12"	2"
1/8	12"	3"
1/6	12"	4"
1/4	12"	6"
1/3	12"	8"
1/2	12"	12"
3/4	12"	18"

The "stepping method" is the easiest method for measuring and marking rafters. After the pitch as been decided, the numerals to use on the tongue and blade are located. The square is then set on the edge in the rafter stock as shown in Step No. 1 in the above transparency. The plumb line is marked in the first step. A line is drawn at each outside edge and at the numerals used on the tongue and blade of the square. For the second foot of run, the square is moved to Step No. 2. (The numeral on the tongue is placed on the mark made by the numeral used on the blade in the preceding step.) For the third foot of run, the square is moved to the third position, etc. The square is moved as many times as there are total feet of run. Framing square clips which may be fastened to the square to maintain the correct measurements are available. After the required number of steps have been taken, the seat cut is marked. This is accomplished by measuring the distance on the plumb line or depth of the seat cut and moving the square to the right on the board until the square is "lined up" with the depth mark. A level line is drawn along the square at the point.

Next, the length of overhang or tail is determined. It may be most any length. The length is measured from the plumb cut at the seat and on the top edge of the rafter. Several different cuts can be made at the end of the overhang, but usually a plumb cut is made.

If a ridge board is used, one-half of the width of the ridge board must be removed from the top end of the rafter. After the measurement is taken, a line is drawn perpendicular to the plumb line.

Rafters for a shed roof are cut in the same manner; however, two seat cuts

are made; and the run is the width of the building.

To determine the length and proper seat cuts for a shed roof that does not have a standard pitch the builder only needs to determine the number of inches of rise per foot of span. The number of inches of rise per foot of span and fractional inches are used on the tongue of the square, and 12 is used on the blade. A step on the square is taken for each foot of span. For example, for an eight foot wide building with one wall 30 inches higher than the other wall, the numerals to use on the tongue would be 3.75 inches (30"÷8' = 3.75 inches, or 3.75 inches per foot of run).

Valley and hip rafters are "stepped off" in the same manner as common rafters, except 17 is used on the blade instead of 12.

Jack rafters are the same length per foot of run as common rafters with the same pitch. The lower plumb cut of a hip jack and upper plumb cut of a valley jack are the same as these cuts on a common rafter. Some difficulty may be experienced in determining the length and side cut on the hip jack and valley jack and in getting the proper fit against the hip and valley rafters. The sidecuts, however, for these may be found on a good framing square.

Generally the first rafter cut for common and shed rafters are used as a pattern for marking the other rafters of the same kind and length.

Prior to cutting a rafter and before ordering the lumber for rafters, the builder will need to determine the length of rafter stock to order. Several methods may be used to determine the length of the stock needed. The simplest method is to measure the distance between 12 on the blade (run) of the square and the rise per foot of run on the tongue. This distance is multiplied by the number of feet of run in the building, and the overhang measurement is added to this. For example, there are 14.42 inches per foot of run when an 1/3 pitch is used. For a building with 10 feet of run and 16 inches of overhang on the rafter, the rafter stock should be 16 feet long (10 x 14.42 = 144.20 inches ÷12 = 14.42 feet + 16 inches overhang = 15.82 feet. The rafter stock should be 16 feet long.) The rafter and framing table on the square also will provide the builder with the length of rafter per foot of run. Charts providing the same information are also available.

11. Roof Trusses

A truss is a structural framework made of lumber or metal and is composed of a number of members fastened together. They are constructed so that the external load will cause only direct stress on the members.

Trusses allow the builder to cover a large area with a clear or post free span and are particularly adapted to pole buildings. Properly constructed trusses

can be spaced at great intervals, and the lumber used in building trusses does not have to be cut to an exact fit. Some disadvantages are a jig must be constructed; trusses must be built on the ground; and special equipment may be required to raise them in place. Also, unless a number of trusses are to be built, their construction may require more labor. Trusses must be constructed to specifications; otherwise, they will not have the strength desired.

Transparency No. 10

The size of each part of a truss and the method used to join the members depend upon the span, slop (pitch), and load. The top chord serves as the rafters, and sheathing and other roofing parts are fastened to it. If the building will have a ceiling, it is fastened or hung from the bottom chord. The parts may be fastened by several means. Wood or metal gussets and bolts and split rings are two methods.

12. Framing a Building

The framing method used depends upon the type of building and materials to be used in the structure. In pole buildings, the framing is attached to the poles, and the siding is attached to the frame. The size of framing materials will depend upon the strength desired, type of siding to be used, and cost.

Transparency No. 11

The three most common kinds of frames are poles, platform, and balloon. Each floor is framed separately in platform framing. For example, in the construction of a two-story building, the first floor is framed, room partitions are placed, and the sub-floor for the second story is placed on top of the first floor frames and partitions. If balloon framing is used, the studs are long enough to frame the exterior walls for both floors. The joists for the second floor rest on ribbon boards and the top of the first floor partition walls.

Transparency No. 12

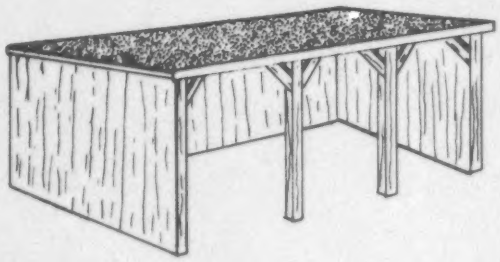
The sills rest on and are joined at the foundation (poles, concrete slab, etc.) and are single or doubled 2 x 4, 2 x 6, or 2 x 8. If the foundation is concrete, an anchor (bolt or other type of anchor) is used to join the foundation and sill. The anchor is embedded in the concrete when it is placed. Anchors prevent the building from shifting under high wind pressure. Three kinds of sill construction are shown in the above illustration.

References:

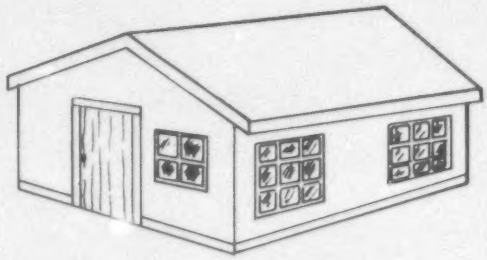
1. "Utility Buildings", American Association for Vocational Instructional Materials, University of Georgia, Athens, Georgia, 1974.

2. Durbahn, Walter E. and Elmer W. Sundberg, Fundamentals of Carpentry, Vol. 2, American Technical Society, Chicago, Illinois, 1972.

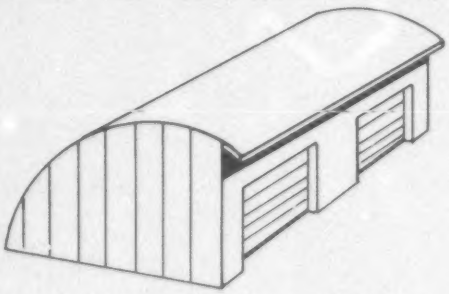
ROOF TYPES



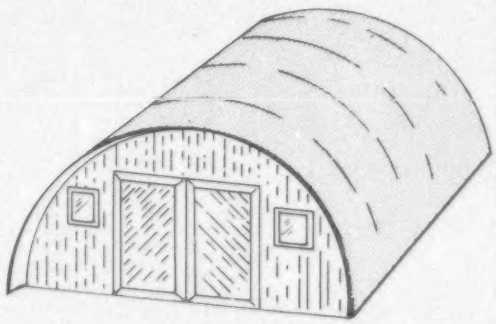
SHED ROOF



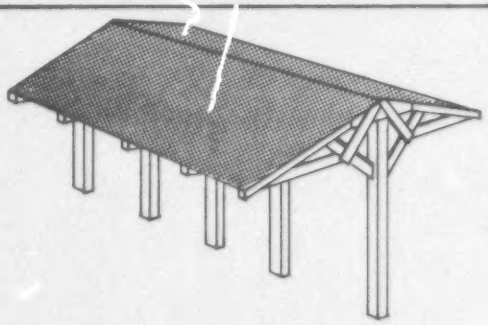
GABLE ROOF



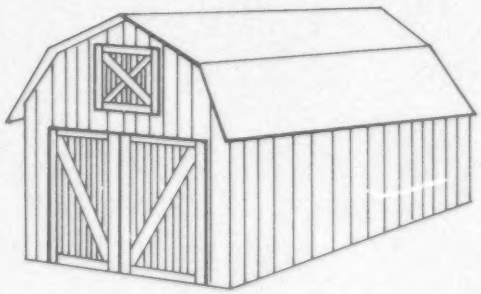
HALF-ARCH ROOF



FULL-ARCH ROOF

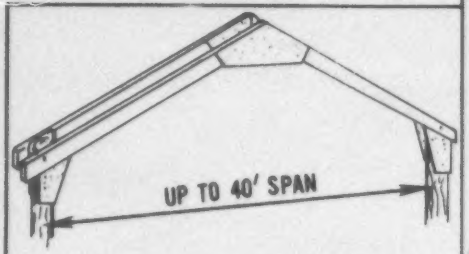


UMBRELLA ROOF

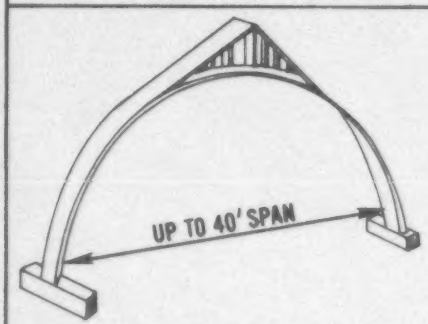


GAMBREL ROOF

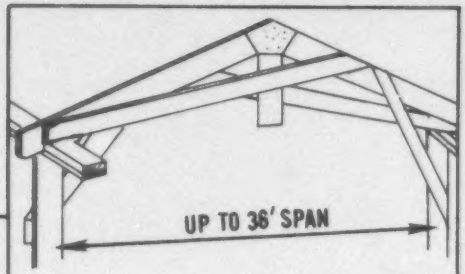
TYPES OF ROOF FRAMING

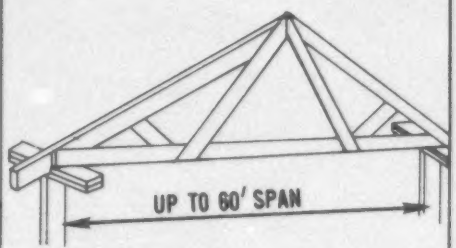


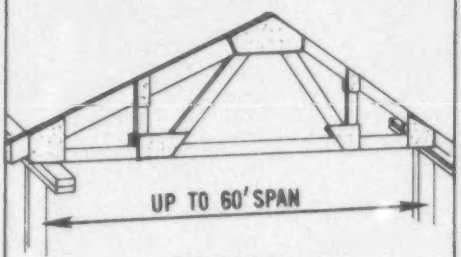
RIGID-WOOD FRAME



CURVED-ARCH RAFTERS

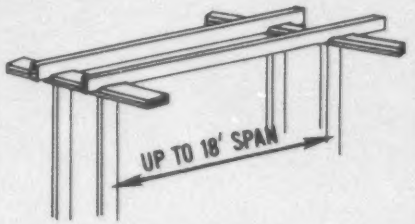




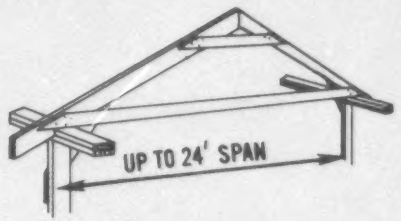


TRUSSES

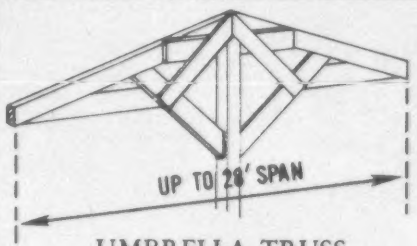
WIDE SPANS



SHED ROOF RAFTERS



GABLE ROOF RAFTERS

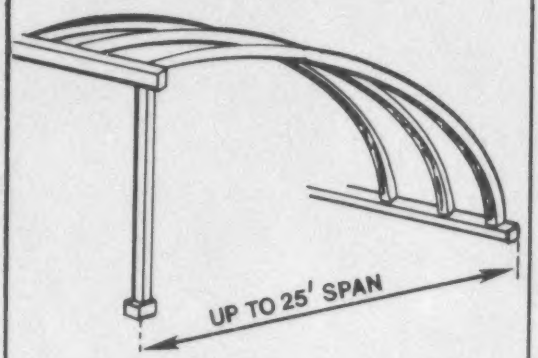


UMBRELLA TRUSS

NARROW SPANS

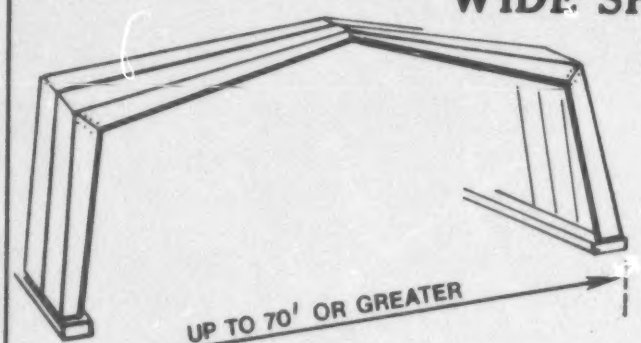
MANUFACTURED FRAMING MATERIALS

NARROW SPAN

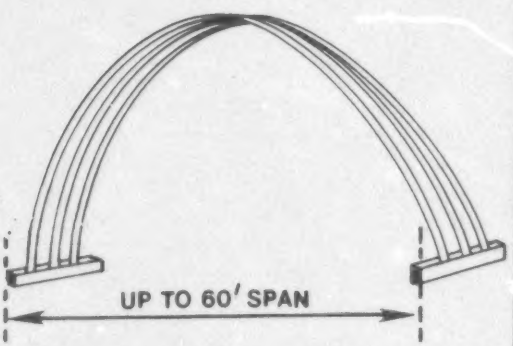


HALF-ARCH FRAME

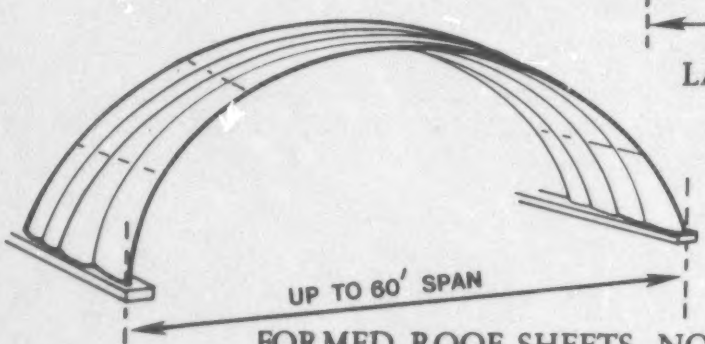
WIDE SPANS



RIGID STEEL FRAME

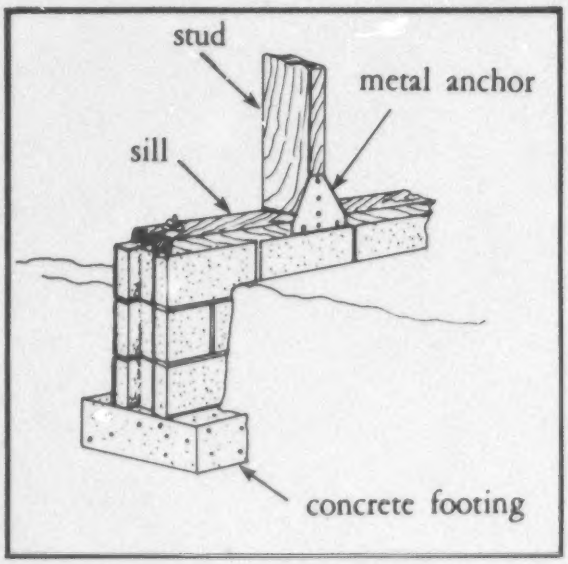


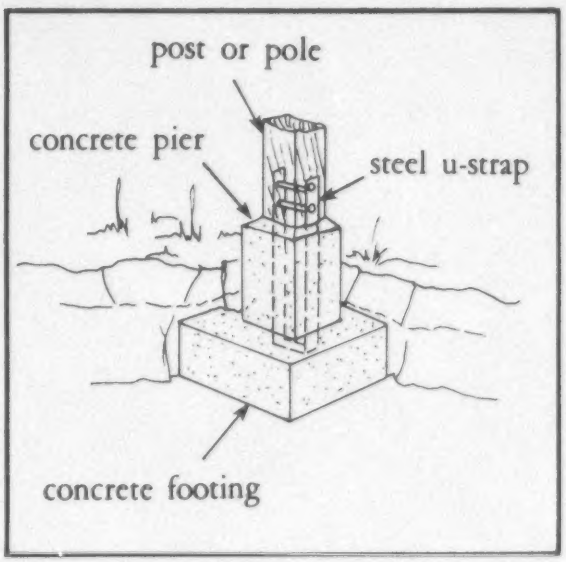
LAMINATED or STEEL FRAME RAFTERS

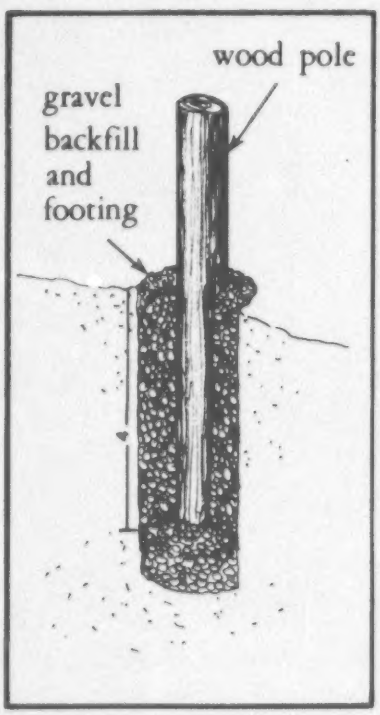


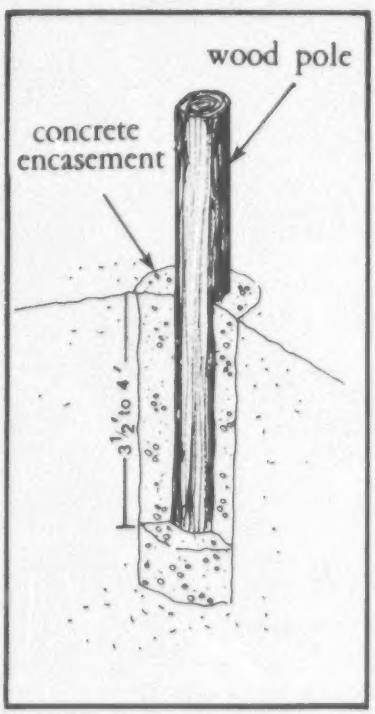
FORMED ROOF SHEETS, NO FRAME

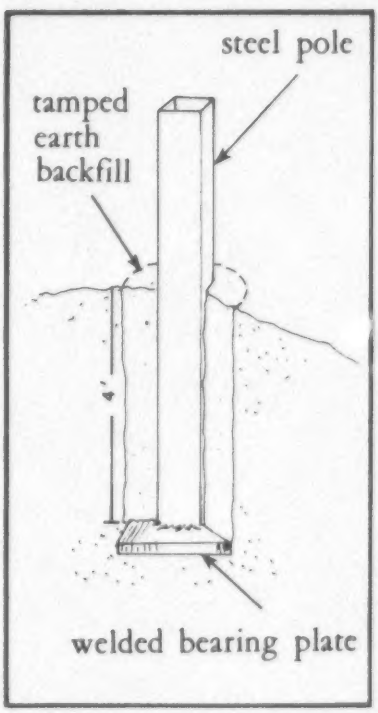
FOUNDATIONS AND WALL SUPPORTS



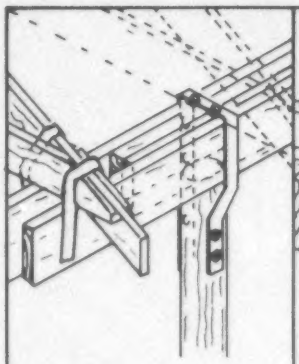




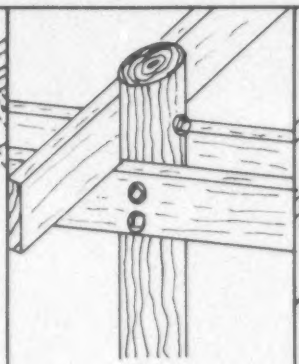




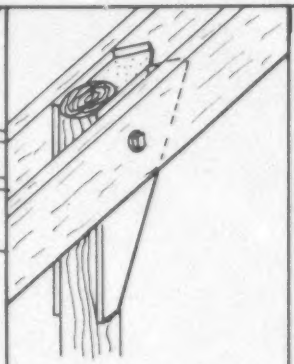
ANCHORING ROOF FRAMINGS



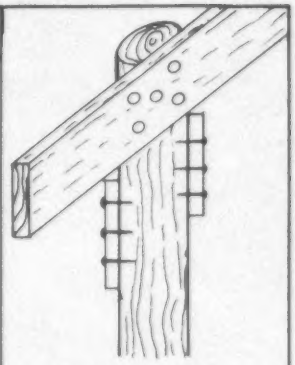
Steel straps attaching lintel & truss to girder



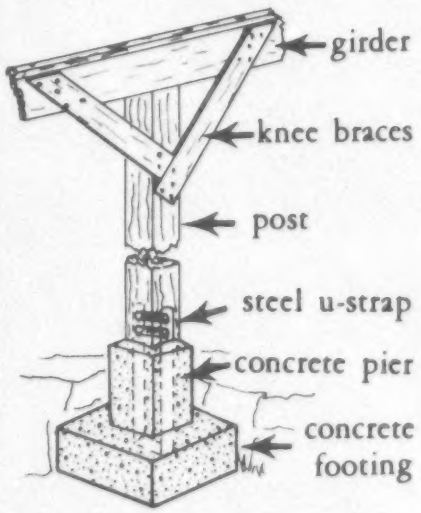
Bolts attaching girder & roof framing



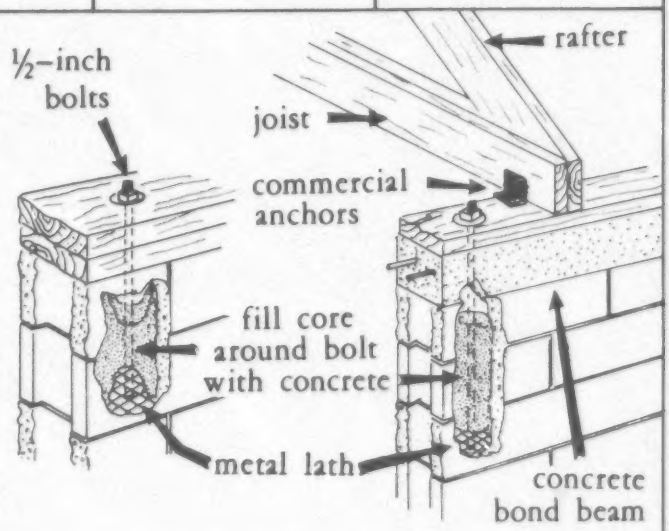
Gusset plates & bolts attaching rafters to pole



Nails attaching purlins & rafters

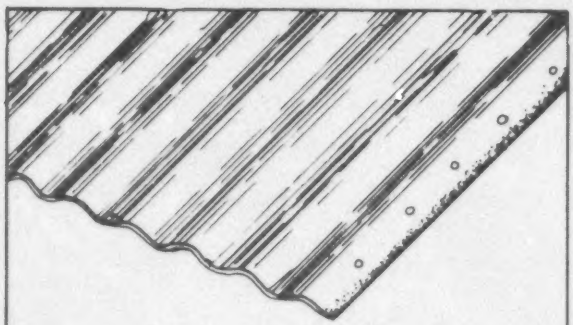


POST & PIER BRACING

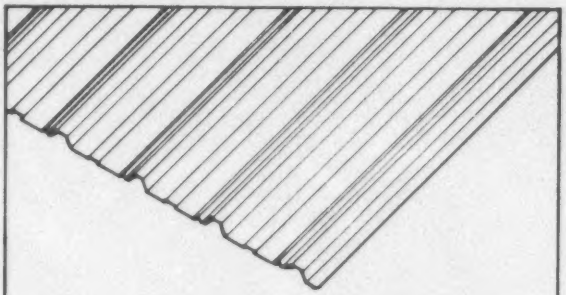


ATTACHING ROOF FRAMING TO MASONRY WALL

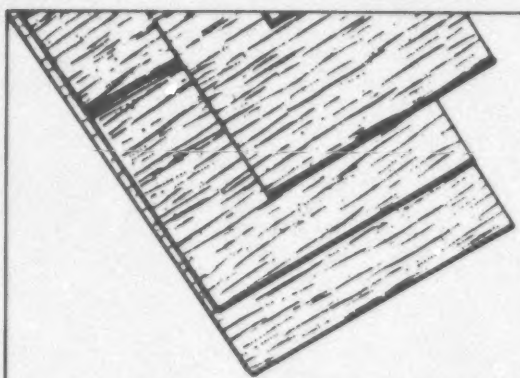
ROOFING MATERIALS



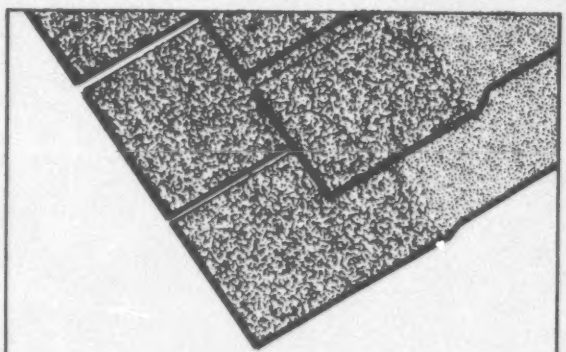
ASBESTOS-CEMENT



STEEL OR ALUMINUM

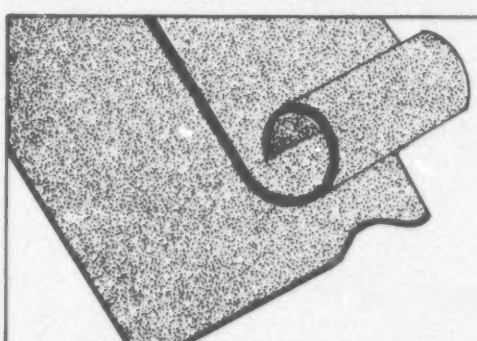


WOOD SHINGLES



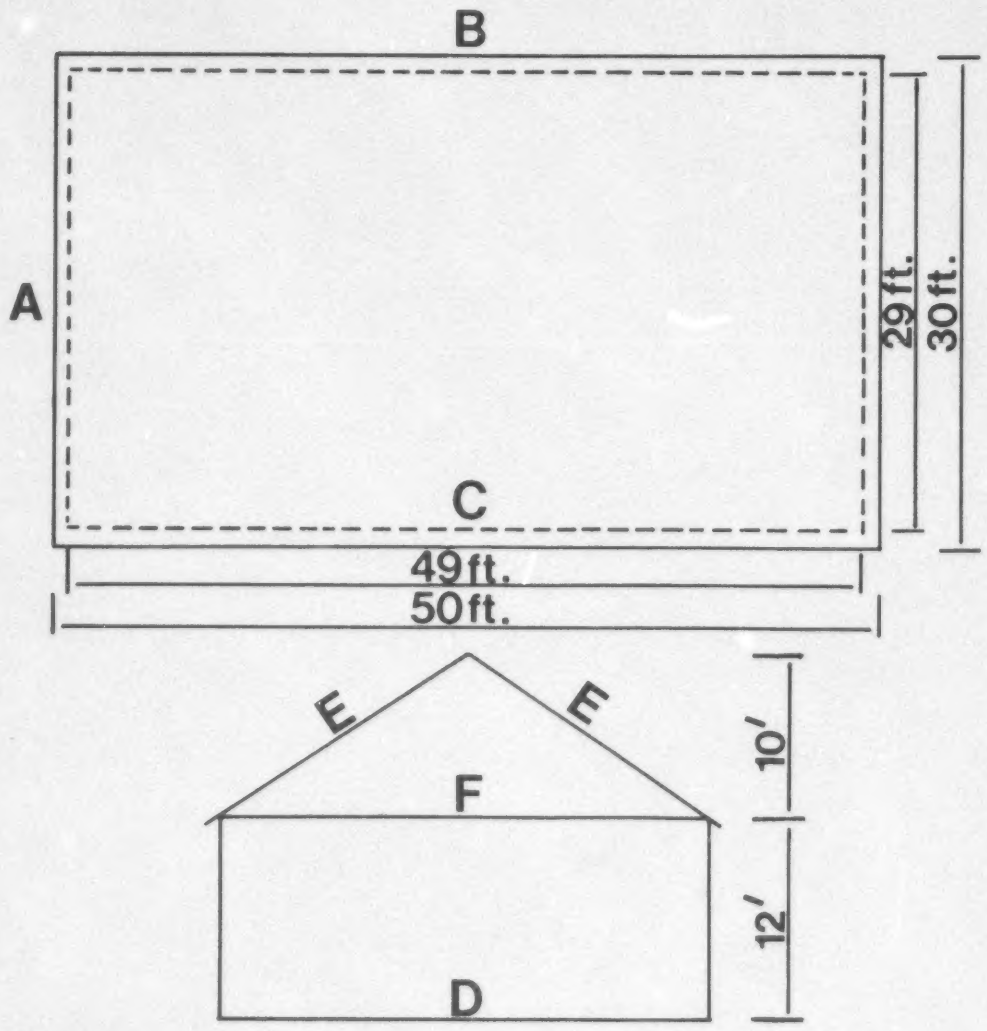
ASPHALT SHINGLES

SELVAGE-EDGE ROLL



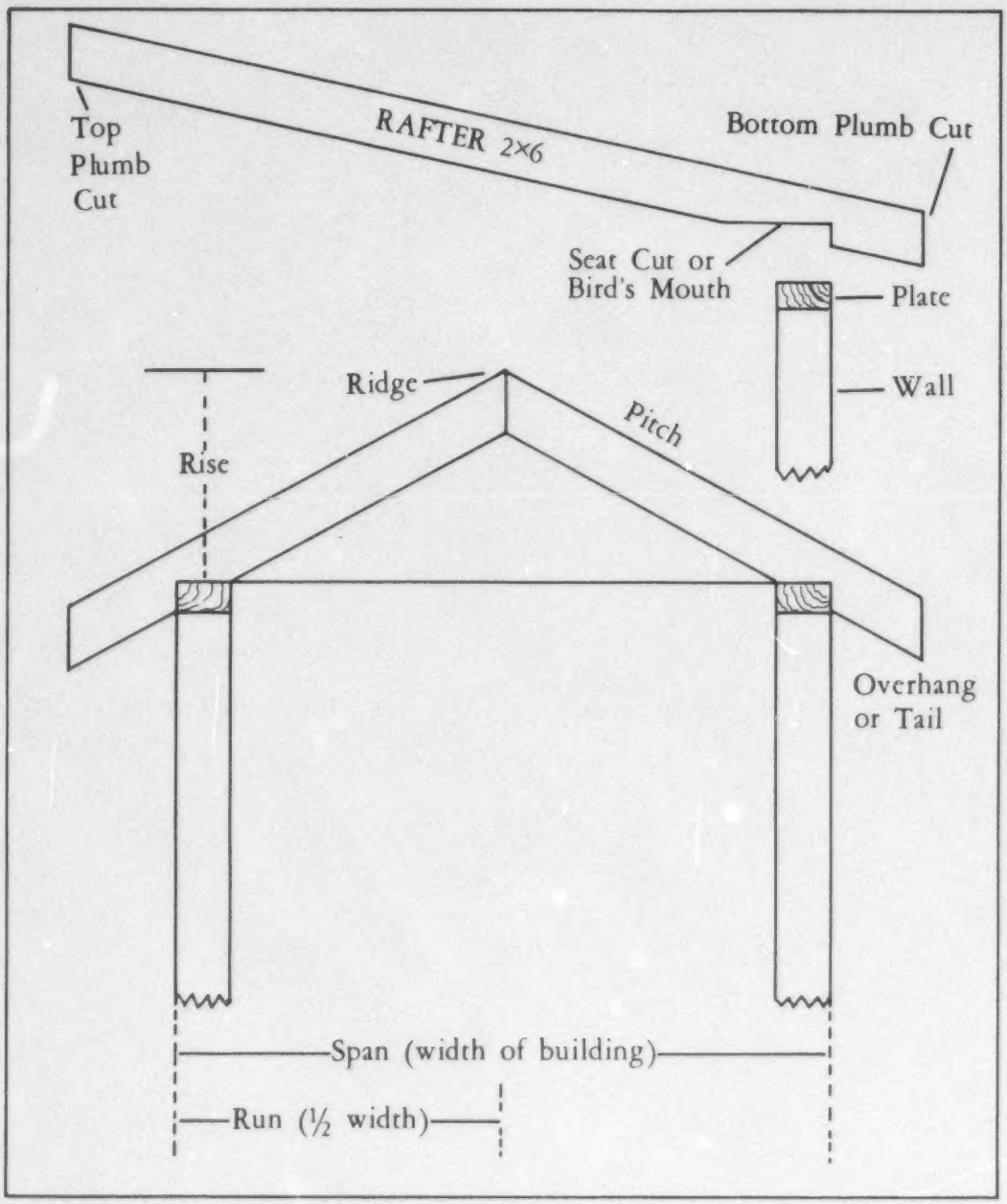
SMOOTH-SURFACED ROLL

CALCULATING BUILDING MATERIALS BY AREAS

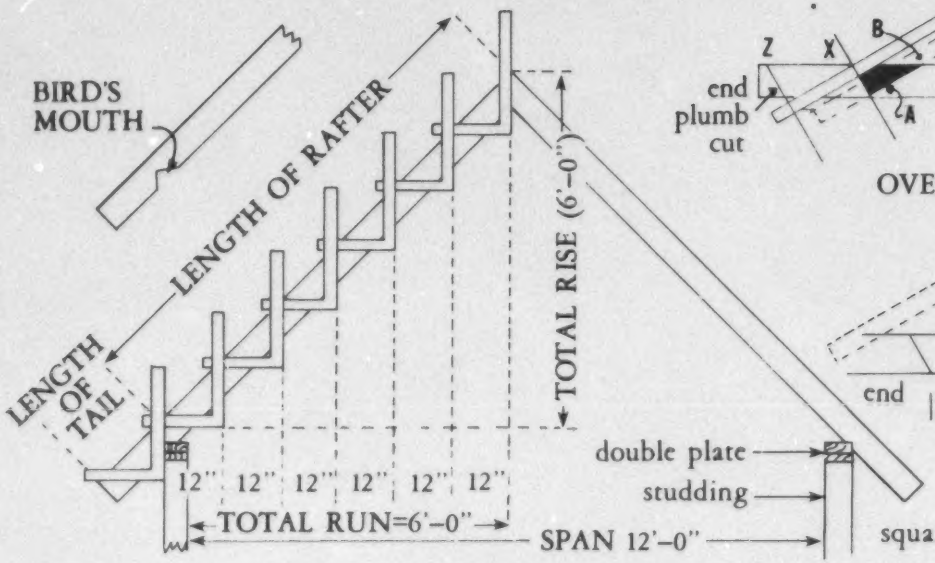


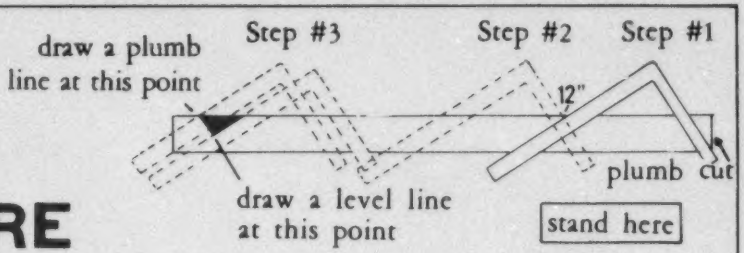
Scale: 1 inch = 10 feet

RAFTER CUTTING TERMS

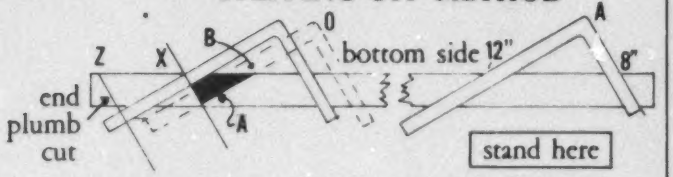


LAYING OUT RAFTERS WITH THE SQUARE

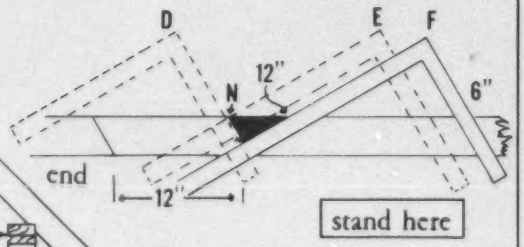




STEPPING-OFF METHOD



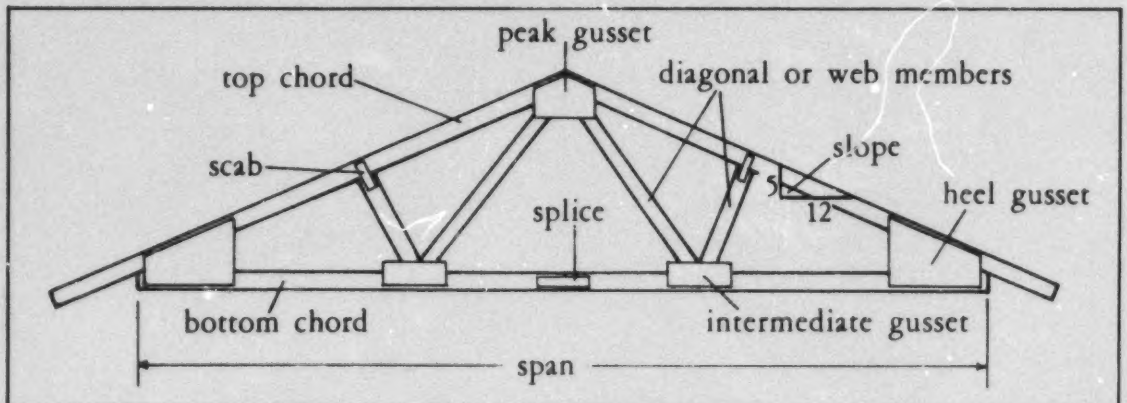
OVERHAND MEASUREMENT



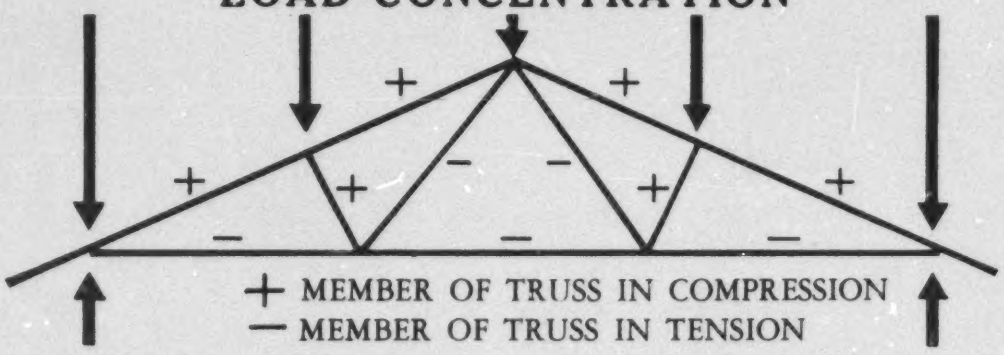
MAKING THE SEAT CUT

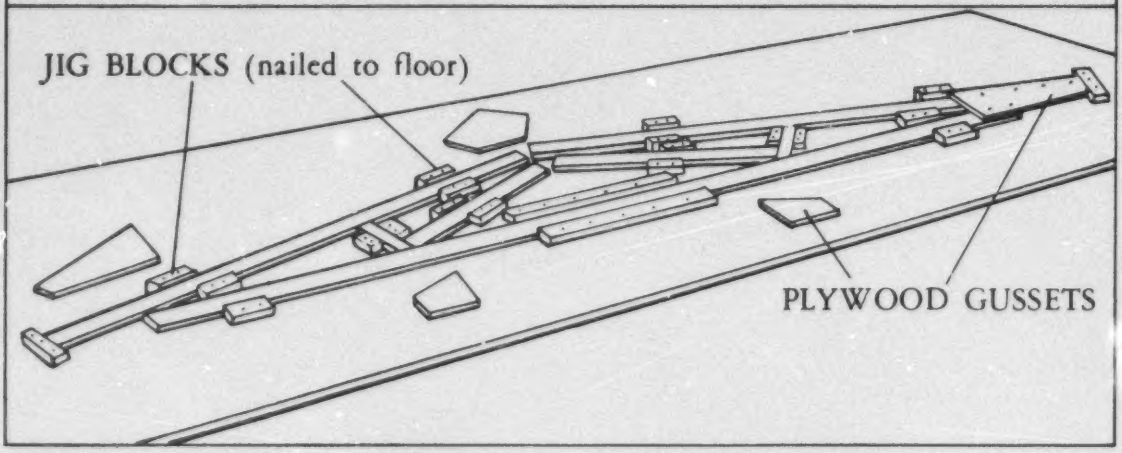
PITCH=RISE DIVIDED BY THE SPAN.

TRUSS PARTS & LOAD

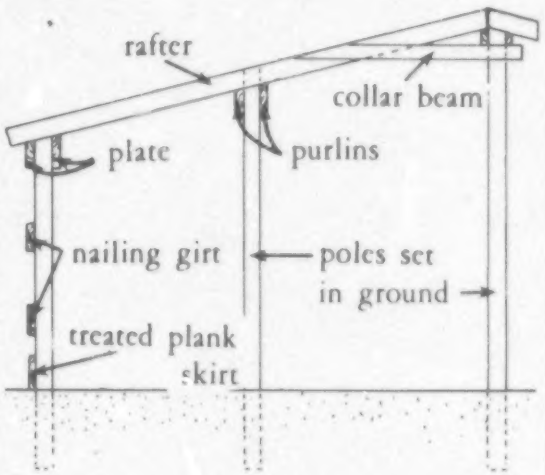


LOAD CONCENTRATION

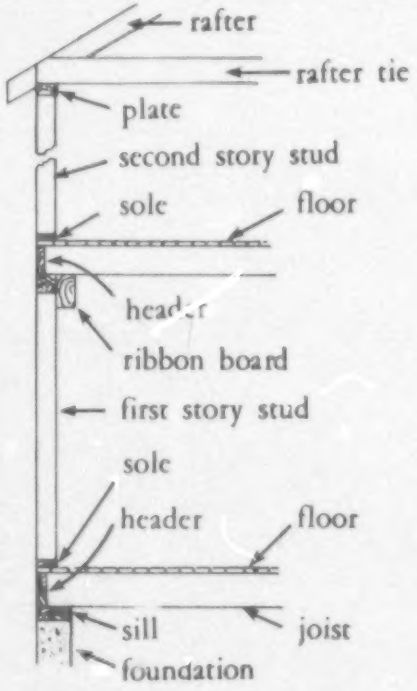




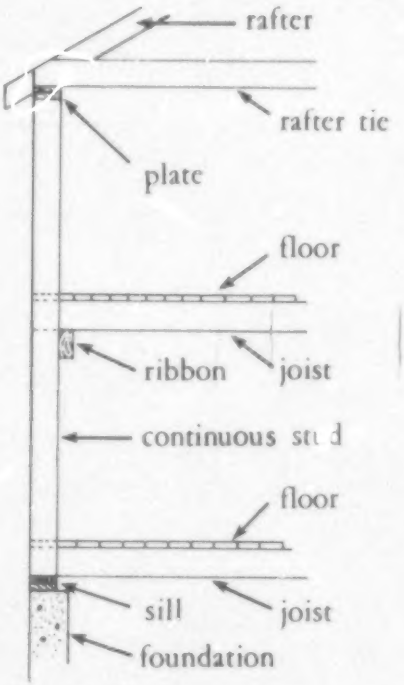
TYPES OF WOOD-FRAME STRUCTURES



POLE FRAME

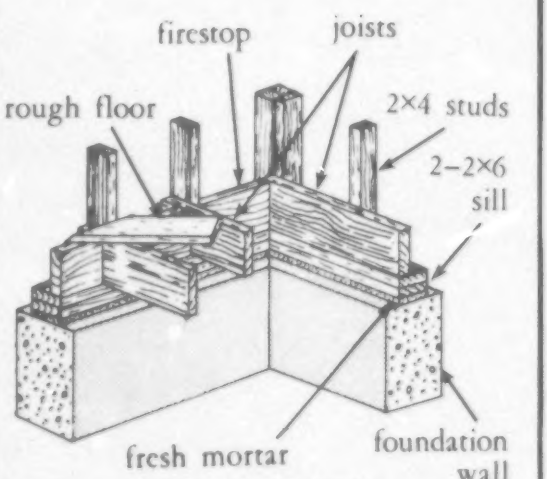


PLATFORM FRAME
each floor is framed separately

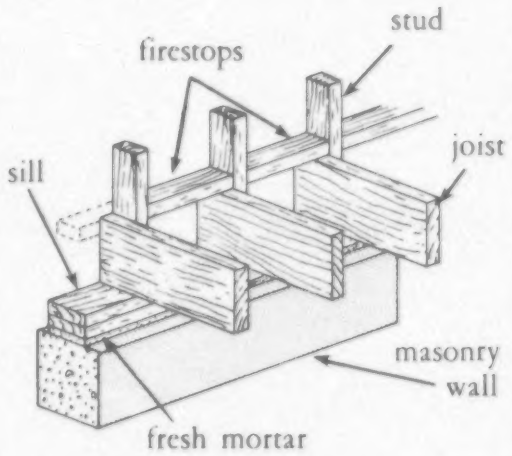


BALLOON FRAME
studs extend the height of both stories

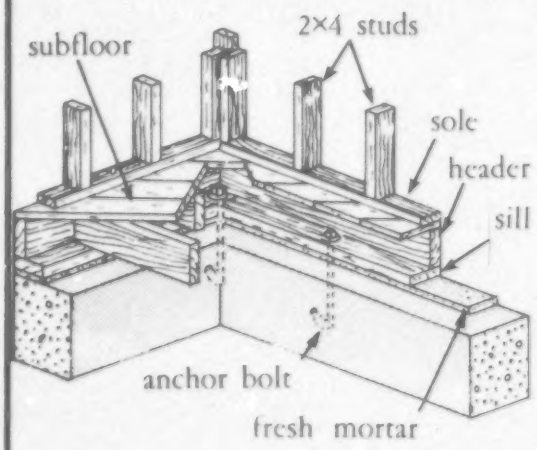
KINDS OF SILLS



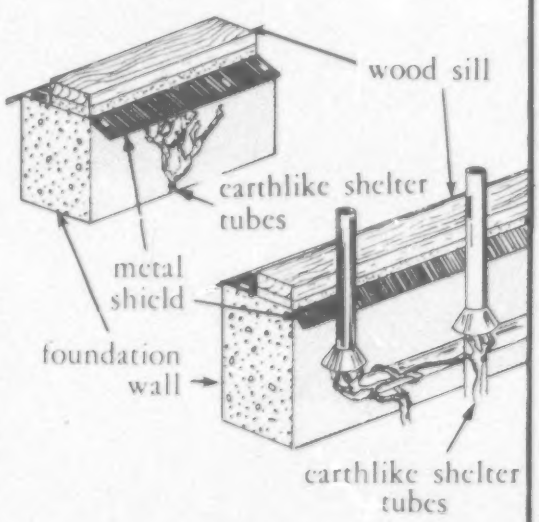
SILL FOR BALLOON FRAMING



ALTERNATE SILL FOR BALLOON FRAMING



BOX SILL



TERMITE PROTECTION

CONSTRUCTION AND MAINTENANCE

Unit B: Farm Carpentry

Topic 2: Computation of a Bill of Materials

Suggested Procedure and Activities: Miniature buildings and equipment will be helpful in explaining the dimensions of materials. Transparencies may also be used as a teaching aid.

1. The Importance of a Bill of Materials

The agricultural builder usually thinks about the cost of a new building or a piece of equipment before a completed sketch is sent to the drawing board. The cost is partially determined by a bill of materials.

a. A complete bill of materials will show the kinds of material required, the dimensions of materials, and the amount of each kind needed.

Plans for buildings and equipment are usually accompanied by a list of materials. If an adequate bill of materials does not accompany the construction plans, a list should be made before initiating the building program. A bill of materials will reduce waste of materials and save time. For example, lumber may be purchased at the desired dimensions, steel at the desired length, and concrete at the proper number of cubic yards needed for a job. If lumber or metal roofing is too long, it must be cut to the proper length. This may result in waste.

2. The Meaning of a Bill of Materials

A bill of materials gives the number of pieces, dimensions of each piece, kind and amount of material, and, in some cases, where the material is to be used. A list of materials for a farm pole building may include poles, lumber, concrete or gravel, metal roofing, nails, and hardware. Simply stated, a bill of materials is a list of materials which gives the amount, size, and kind to be used on a specific construction project.

3. How to Prepare a Bill of Materials

A working sketch usually contains a very simple set of specifications for a given job or project. If a large piece of equipment or a building is constructed or repaired, a set of specifications supplementing the drawing will give a bill of materials necessary for the job. The following procedure may be followed in preparing a bill of materials:

a. Study the sketch or drawing (plan) of the building or piece of equipment.

b. Develop a list of materials that will be used first and then make a detailed list needed for the job.

c. Revise the detailed list by making a bill of materials in standard sizes. List the amount of the material for each stock, size, and give its description or use.

d. Attach the list of materials to the sketch or drawing for future reference.

4. The Unit of Measure for Bill of Materials

a. Board Foot - A board foot is a piece of lumber one foot long, one foot wide, and one inch thick. Most lumber is sold by the board foot or by the 1000 board feet and grade classification.

b. Running Foot - A running foot is a piece of material one foot long regardless of width and thickness. Molding, narrow finished lumber (1" x 2"), most pipe used in plumbing, electrical wire, fencing materials, molding materials, certain kinds of metal roofing, and certain types of reinforcement steel are sold by the running foot. A running foot measure is sometimes referred to as line or measure.

c. Square Foot - A square foot is one foot long and one foot wide regardless of the thickness. Wall and floor tile, plywood and other paneling, concrete slabs, metal roofing, plastic materials, and floor covering (linoleums) are usually sold by the square foot. Some masonry materials are sold on the basis of covering a certain number of square feet.

d. Cubic Foot - A cubic foot is one foot wide, one foot long, and one foot high. Cement and some other masonry materials are sold by the cubic foot.

e. Cubic Yard - A cubic yard is 27 cubic feet. It is one yard (3 feet) on all sides. Sand, gravel, fill dirt, and concrete may be purchased by the cubic yard.

f. Gallon - A gallon is a liquid measure. Paint and painting materials are usually sold by liquid measure. The weight of a gallon of paint is determined by its ingredients. A given quantity of paint is supposed to cover a certain number of square feet.

g. Roll - A roll is something that is rolled into a cylinder or ball. Wire fencing, roofing paper, and certain types of roofing may be purchased by the roll.

h. Square - A square is a term used in roofing. It is 10 feet by 10 feet, or 100 square feet. For example, three bundles of asphalt shingles will cover

100 square feet, and a square of metal roofing will cover 100 square feet.

5. Figuring a Bill of Materials

Transparencies No. 1 and No. 2

Bill of Materials for 12' Feed Trough

Item Name	Material	Description
Legs	1-2"x6"-12'	Penta-treated pine
Floor	3-2"x10"-12'	S 4 S No. 2 yellow pine
Sides	2-2"x8"-12'	S 4 S No. 2 yellow pine
Ends	1-2"x10"-6'	S 4 S No. 2 yellow pine
Braces	1-2"x4"-10'	S 4 S No. 2 yellow pine
	2-2"x4"-12'	S 4 S No. 2 yellow pine
	1-2"x4"-6'	S 4 S No. 2 yellow pine
Nails	3 lbs.	16 d common
Paint	1/4 gallon	Latex Barn Red

Lumber that is sold by the board foot is priced per M (1,000 board feet). For example, if 12 foot 2"x8" lumber is priced at $375.00 per M, 1-2"x8"-12'0" piece of lumber would cost $6.00.

$$\frac{1x2x8x12}{12} = 16 \text{ board feet}$$

$375.00 per thousand board feet or
$.375 per board foot
16 x $.375 = $6.00

6. Calculating Board Feet

Transparency No. 3

Lumber prices are figured by the board foot for ordinary lumber. A board foot is the amount of lumber in a piece 1 inch thick, 1 foot wide, and 1 foot long.

Board feet may be calculated by using the board foot formula or the Essex board measure table on the carpenter's steel square.

a. Board Foot Formula: If the lumber length is measured in feet; multiply the number of pieces times the thickness, times the width, times the length, and divide by 12. For example, to find the board feet in 5-2"x4" - 12'0" long, proceed as follows:

$$\frac{5x2x4x12}{12} = 40 \text{ board feet}$$

If the length of lumber is given in inches, use the same procedure already used except divide by 144. For example, to find the board feet in 3-1"x6"-40" long, proceed as follows:

$$\frac{3x1x6x40}{144} = \frac{720}{144} = 5 \text{ board feet}$$

Transparency No. 4

b. Essex Board Measure Table: This table appears on the back of the square body and gives the contents in board measure of almost any size of board. The figure "12" on the outer edge represents a board 12 inches wide and one inch thick, and is the starting point for all calculations. The numbers in the column directly under the 12-inch mark indicate the length of lumber in feet. The regular inch divisions of the square represent the widths of boards in inches. The figures under each of these inch marks represent the number of board feet and twelfths of a board foot.

To find the feet of board measure in a piece of lumber, locate under the 12-inch mark the figure corresponding to the length (in feet) of the lumber. Then follow along the horizontal line on which the length is stamped toward the column of figures under the given width of the lumber. The figure appearing at the left-hand side of the vertical line is full feet board measure, and the figure at the right of the vertical line is twelfths of a foot board measure.

The figures in the tables are given for lumber 1 inch thick. To obtain the board measure for any other thickness, multiply the figure given in the table by the thickness of the lumber.

Example: Calculate the board feet in
1-1"x8" - 10' 0" long.

First find the 10 feet in the column under "12" for the length in feet, then find 8 inches on the top edge of the square for the width in inches. Read the figures in the column on the line corresponding with 10 feet. The number of board feet is 6 8/12 (6-8), reduced to 6 2/3. To find the board feet in 1-2x8 - 10' 0" long, multiply by two (2 x 6 2/3 = 13 1/3 bd. ft.).

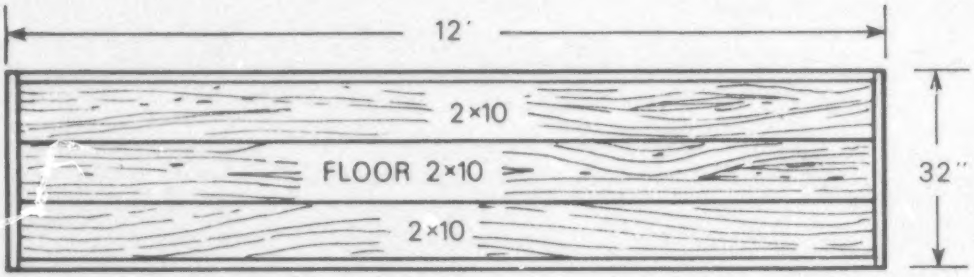
References:

Durbahn, Walter E., Fundamentals of Carpentry, American Technical Society, Chicago, IL 1971.

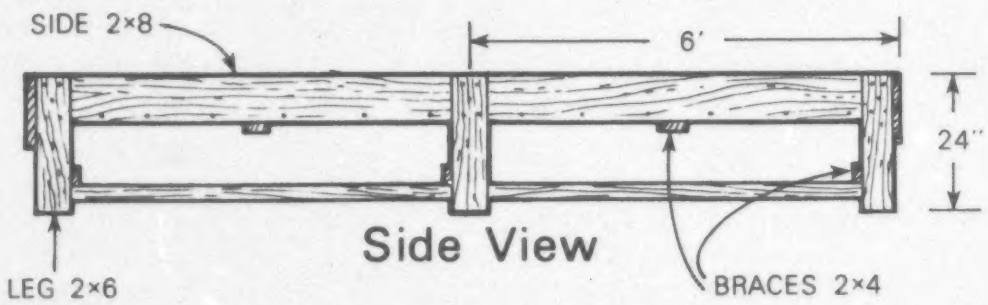
Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, IL 1967.

Wakeman, T. J., Modern Agricultural Mechanics, The Interstate Printers and Publishers, Inc., Danville, IL 1977.

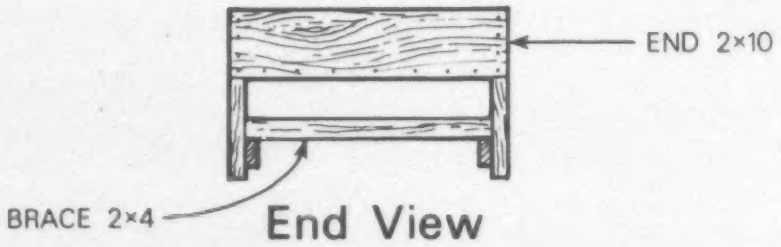
WORKING SKETCH-12 FOOT FEED TROUGH



Top View



Side View



End View

BILL OF MATERIALS - 12 FOOT FEED TROUGH

Item	Material and Description	Amount	Cost per M	Cost
Legs	1 - 2" x 6" - 12' penta	12 bd. ft.	$450.00	$ 5.40
Floor	3 - 2" x 10" - 12' S4S No. 2	60 bd. ft.	375.00	22.50
Sides	2 - 2" x 8" - 12' S4S No. 2	32 bd. ft.	375.00	12.00
Ends	1 - 2" x 10" - 6' S4S No. 2	10 bd. ft.	375.00	3.75
Braces	1 - 2" x 4" - 6'	4 bd. ft.	320.00	1.28
	1 - 2" x 4" - 10' S4S No. 2	7 bd. ft.	320.00	2.24
	2 - 2" x 4" - 12'	16 bd. ft.	320.00	5.12
Nails	16d common	3 lbs.	.50 per lb.	1.50
Paint	Latex Barn Red	1/4 gallon	10.00 per gal.	2.50
			TOTAL	$56.29

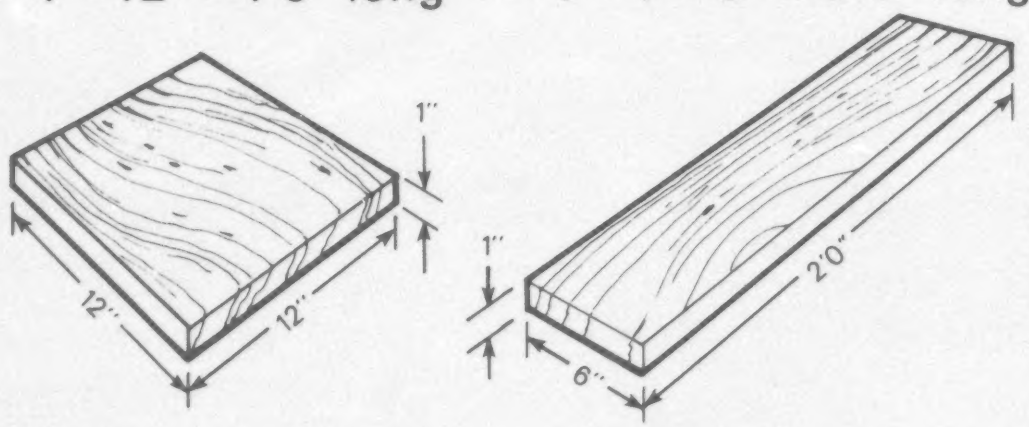
EXAMPLE COST CALCULATION

$$\text{(Legs)}\quad \frac{1\times 2\times 6\times \cancel{12}^{1}}{\cancel{12}_{1}} = 12 \text{ bd. ft.}$$

12 bd. ft. × 45¢ per bd. ft. = $5.40
($450.00 per M)

1 Board Foot =

1 - 1"×12" - 1'0" long OR 1 - 1"×6" - 2'0" long



BOARD FOOT FORMULA

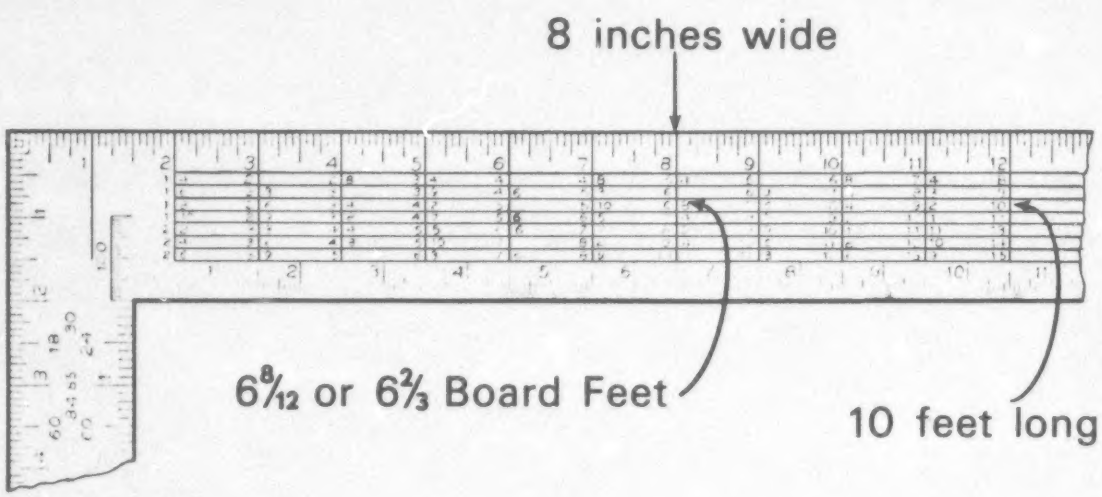
$$\frac{\text{No. of pieces} \times \text{thickness} \times \text{width} \times \text{length}^{\text{(in feet)}}}{12} = \text{Board Feet}$$

EXAMPLE: Board feet in 5-2"×4"-12'0" long

$$\frac{5\times2\times4\times\cancel{12}^{1}}{\cancel{12}_{1}} = 40 \text{ Board Feet}$$

OR $\frac{5\times2\times4\times12}{12} = \frac{360}{12} = 40$ Board Feet

ESSEX BOARD MEASURE TABLE



Example: Board Measure of 1-1"×8"-10'0" long

- Find 10'0" length under "12" column
- Move horizontally to "8" column representing width
- Move vertically down to find board feet

1-1"×8"-10'0" = 6 2/3 Board Feet

CONSTRUCTION AND MAINTENANCE

Unit B: Farm Carpentry

Topic 3: Selecting and Applying Paint

Suggested Procedures and Activities: Labels from paint containers, types of brushes, spray painting equipment, cleaning tools, safety equipment, and samples of paints and ingredients can be used in the classroom during the class discussion.

1. Importance of Painting

Paint protects metal and wood surfaces from corrosion and, in some cases, wear. It adds to the appearance of a machine or building; therefore, the value of the farm machine or building is partially maintained through a good painting program. Machines that are not properly housed during the season that they are not in use must be protected by paint.

Tractors and other types of farm equipment that are traded in on new equipment bring a higher value if the paint is in good condition. A well cared for surface may mean the entire machine is well cared for.

2. Selecting the Proper Paint

About two-thirds of the cost of painting is in the labor; therefore, it is advisable to select a lasting, good grade of paint in order to reduce the number of paint jobs. Good grades of paint contain the correct amount of ingredients. For example, a good paint may contain 60 percent pigment and up to 40 percent vehicle. Enamels contain 40 percent pigment and 60 percent vehicle. In areas where hydrogen fumes and mildew are a problem, the pigment should contain between 18 and 40 percent zinc oxide.

Metal paints should contain rust inhibitors such as red lead, metallic zinc, blue lead, or zinc chromate. Also, the primer coat should contain an inhibitor. This coat adheres directly to the metal surface; therefore, it prevents the metal from oxidizing. Ordinary paints do not contain an agent that prevents or limits rust. Regardless of the type of metal paint used, the directions on the label should be followed.

Some surfaces must be cleaned with a solvent or soap and water occasionally; therefore, a paint must be selected that will withstand cleaning.

3. Types of Paint

Enamel - This paint is used mainly for inside woodwork. It contains a varnish instead of a drying oil.

Rubber-Base - Rubber-base paints have taken the place of many interior oil paints. Synthetic rubber is emulsified in such a way that it mixes with water. It may be brushed on a surface or rolled on.

Outside Paint - Exterior paint may have an oil vehicle (liquid part of paint), which is either raw or boiled linseed oil or a water base. The pigment may be titanium dioxide, white or red lead, zinc oxide, or iron oxide.

White lead pigment is used in exterior paint.
Red lead pigment is one of the best metal primers.
Zinc oxide causes the paint to be mildew resistant.
Iron oxide is considered one of the most durable outside pigments.

Aluminum - This paint is used on metal after a coat of red lead or blue lead paint has been used. It is made of aluminum powder and spar varnish. It will stop the bleeding through of lead paints or creosote.

Cement - Cement water paints are used to prevent moisture entering masonry walls. Usually the paint is brushed into the surface where it forms a hard protective film over the masonry.

Other Paints - Several other important paints include:

Varnish - Varnish is made of gums, resins, and oils. It can be found for either exterior or interior use.

Shellac - This paint is made of gum and alcohol. It is mainly used on wood finish to preserve the paint beneath it.

Metallic Zinc - This paint is used on metals to prevent rust. Two coats will last more than 10 years.

Casein - Casein paint forms a hard film on interior surfaces, and it can be washed.

Calcimine - This paint is used for interior painting. It cannot be washed. Calcimine is spread on walls with a large brush or roller.

It is important that labels be studied on paint containers to determine paint composition. For example, a maximum for extenders (ingredients with little hiding power and film durability) should be 10% or less.

The most common extenders are silica, calcium carbonate, and magnesium silicate.

Low grade paint lacks the following:

Lasting power or durability
Ability to cover the surface
Quality to prevent cracking, chalking, peeling, and alligatoring
White lead to take the place of low grade fillers

4. Surface Preparation

a. New Surfaces - New surfaces usually require less time to prepare than old ones. Steps in preparing wood and metal surfaces include:

Smooth the surface if necessary.

Wipe the surface clean of all dust, moisture, grease, and other matter that may interfere with a good paint job.

Use a good rust inhibiting primer for metals.

Use a good crack or hole filler for wood surfaces.

b. Old Surfaces - Old surfaces are more difficult to prepare than new surfaces.

Steps in preparing an old surface are:

Use a mild caustic compound with steam or hot water to clean farm machinery. Kerosene and other cleaning solvents can be used if steam is not available. Compressed air, a putty knife, wire brush, emery cloth, and a screwdriver are necessary items to remove paint from metal.

If bolts are present, they should be tightened before paint is applied.

All repair work should be completed on farm machinery before it is painted.

Using a blow torch or a good liquid paint remover is the easiest way to clean farm machinery of old paint. This practice will require scraping the old paint off, sanding the surface and applying a priming coat.

Steps in preparing painted wood are:

All repair work should be accomplished before repainting is started.

The painted surface can be prepared for repainting by cleaning it with a solvent saturated cloth, brushing, washing, and sanding. All loose or cracked paint, putty, wood filler, oil, dust, and undesirable matter should be removed.

All cracks or areas that need filling should be filled with putty or a wood-filler.

Any loose screws or bolts in the wood objects should be tightened.

Transparency No. 1

5. Problems Encountered in Applying Paint

a. Paint Failures - There are six major causes for the failure of paint to give long protective coating. The causes are:

Blistering and Peeling - Blistering is caused by moisture collecting behind the paint, or moisture in the wood or on the surface at the time of painting. Almost all painting is done where the surface is dry.

Cracking and Scalding - Cracking is caused by the surface expanding and contracting. A high grade of paint will have a more elastic effect to prevent this paint failure.

Running and Sagging - Paint applied too thickly or a paint containing too much oil will run or sag. Also, a glossy surface may cause paint to sag. A glossy surface should be sandpapered before it is painted.

Wrinkling - Wrinkling is a common cause of paint failure. If the surface dries before the paint underneath dries, it will wrinkle. A drop in temperature, thick coat, or too much oil are some of the main causes of wrinkling. Wrinkles should be sanded out before repainting.

Checking - This failure in painting is the result of not mixing the proper proportions of thinner and oil and failing to allow paint to dry between coats. The fine hairlines that appear in checking are only in the outer coat.

Chalking - Surface that has been painted for a long period of time may have a tendency to chalk. The pigment will stick to anything it touches. Low grade paints chalk more easily than high grade paints.

b. How to Determine the Amount of Paint Needed - The amount of paint needed is estimated as follows:

The amount of paint required to cover a surface depends upon whether or not the surface is smooth or rough, the skill of the painter, and the type of material used to make up the surface. High grade paints may cover over 500 square feet for the first coat and over 600 for the succeeding coats.

The approximate area a gallon of paint will cover is estimated as follows:

Height x length of surface to be painted.

"Height with gable" is gable height x half the gable width.

Include the window and door areas. It takes more paint to paint around the openings.

Divide the total square feet by the recommended coverage listed on the paint label. For example:

A building 30 feet long, 10 feet high, 25 feet wide, and 1 gable 6 feet high has a total outside area of 1250 square feet.
2 x 30' = 60' (sides)
2 x 25' = 50' (width)
10 x 110' = 1100 square feet around building
6' x 12-1/2 (1/2 gable width) = 75 feet square one gable end
2 x 75 = 150 square feet + 110 square feet = 1250 square feet

$$\frac{\text{1250 sq. ft.}}{\text{500 sq. ft. per gal.}} = \text{2-1/2 gallons to paint the building}$$

c. Equipment and supplies needed are:

Paintbrushes - 1 inch for small trim, 1/2 to 2 inch for average type trim, and 3-1/2 to 4 inches for other larger surfaces. The best brushes are made of 100% hog bristles.
Paint scraper
Wire brush
Putty knife
Hammer, nail set, and wrenches
Mixing bucket and paddle
Ladders
Putty and wood filler
Sandpaper, emery cloth, and rags
Thinner and solvents for cleaning

Transparency No. 2

d. Paint is mixed by pouring the thin material off the pigment, stirring the pigment with a paddle, adding the thin material to pigment, and continuing to stir until the paint is mixed.

6. Brush Painting

a. Hold the paint brush by placing the thumb over the small part of the brush handle with the fingers resting on the brush ferrule (large part of brush).

b. Dip about one-third the length of the bristles into the paint.

c. Remove the excess paint from the brush by wiping one side against the paint bucket.

d. Apply paint to a surface by bringing the brush against it very lightly, then make long sweeping strokes in the same direction to form a thin uniform film. The brush should be lifted gradually at both ends of the stroke to form a thin film. Apply the paint with the grain on wood surfaces.

7. Important Things to Observe in Painting

a. Paint during dry seasons when the temperature is about 65 degrees.

b. There are several grades of paint. Due to its lasting effect and cost of applying, the best grades are usually the cheapest.

c. While painting rough surfaces use the brush in several directions to force paint into the wood.

d. If the paint brush is used for more than a day, it may be immersed in linseed oil or paint thinner. At the end of a painting job the brush should be washed several times in kerosene or paint thinner, then washed in soap and water. A brush used in water-thinned paints should be washed daily with soap and water. The shape of brush bristles can be maintained by wrapping them in paper after they have been washed.

8. Spray Gun Painting

A mechanical means of applying paint is used by manufacturers who make farm machinery, trucks, automobiles and tractors, and many other types of equipment found around the home and farm. Spray painting is similar to brush painting in that it improves the appearance and life of an item, thus making it more valuable.

There is little comparison in the cost of spray painting and brush painting equipment. If there is much painting to be done, the labor required to brush paint will offset the cost of good spray painting equipment.

Spray painting is the best way to paint concrete, rough lumber, wood shingles, farm machinery, fences, and farm buildings that have few openings.

An area or piece of machinery can be painted more rapidly with a spray gun than with a brush. It is estimated that a spray gun will cover five to twenty-five times the area that can be covered with a brush in the same period of time. This is one reason why farm machinery repair shops and manufacturers use the spray gun instead of the paint brush.

9. Spray Painting Tools and Supplies

a. Suction or Pressure Type Gun - The pressure type is recognized as the most popular spray gun.

b. Air Compressor

c. Paint Pressure Tank

d. Hose to convey air and hose to convey materials (paints)

e. Air controlling device (gauge and regulator on tank)

f. Respirators

g. Mixing equipment

Transparency No. 3

10. Parts of the Spray Gun

a. Air Cap - This cap controls the spray pattern, and the amount of air consumed. There are two types of caps - external and internal.

b. Fluid Tip - The fluid tip is a nozzle through which the paint passes to enter into the stream of air. It is located just back of the air cap. Fluid tips help regulate the amount of paint flow, and it can be found in different sizes.

c. Fluid Needle - This needle enters the fluid tip and permits the paint to flow, or it stops the flow.

d. Trigger - The trigger pulls the needle out of the fluid tip or forces it back into the tip. Forcing the trigger to the rear opens the air valve on nonbleeder types of guns. If the trigger is further depressed the paint valve is opened.

e. Fluid-Needle Adjustment Screw - The amount of paint that passes through the fluid tip is regulated by an adjustment screw.

f. Air Valve - This valve is found on nonbleeder type guns. The passage of air through the gun is controlled by the trigger movement.

g. Spreader Valve - The spreader adjustment valve controls the air flow to side holes located on the air cap.

11. Types of Guns and Cups

a. The two types of guns are:

Nonbleeder-Type - Air flow is shut off when the trigger is released in the nonbleeder gun. The air and paint is controlled by the trigger.

Bleeder-Type - The air flows constantly through this gun. Paint flows through the fluid tip when the trigger is squeezed.

b. The two types of cups are:

Suction Cup - This cup has a bent hole that permits the outside pressure to enter the cup and help force the paint into the gun. The air stream that passes the end of the tip draws the paint forward. Paint should be thinned for the suction cup. The paint nozzle extends beyond the air cap opening where it is atomized. Suction cups are one quart or less in size, and they are attached to the gun.

Pressure Cup - This air-tight cup may be as large as two quarts. Air pressure entering the cup forces paint from it as the trigger is squeezed. The paint or fluid tip is flushed with the air cap opening. Usually, a smoother finish can be made with the pressure cup than with a suction cup because the air is used for atomization instead of siphoning. Pressure guns can handle heavier paint than siphon guns.

12. Pressure Tanks

a. Pressure tanks are used for handling a large volume of paint. Unlike the pressure cups, the tanks are used to cover larger areas. Most tanks range from two to more than 100-gallon capacity.

b. Air pressure enters the tank through a regulator that is mounted on the lid. The gun's front hose supplies paint, and the back hose supplies atomizing air to the gun.

13. Selecting a Spray Gun

a. Nonbleeder guns are used with a tank or cup of compressed air. The air is regulated to a constant pressure. Bleeder guns are used with a continuous running compressor.

b. A pressure-type gun will spray paints that are heavier than light enamels and lacquers.

c. Internal-mix nozzles are used with pressure equipment and slow drying paints. The paint and air are mixed inside the nozzle. This type of nozzle is used where ordinary finish is desired.

d. External-mix nozzles are operated by either suction or pressure. They can be used with heavy or light paints to form elongated or round patterns. More air pressure is required for operating than for the internal mix nozzle.

14. Using the Spray Gun

a. Preparing Surfaces - Surfaces for spraying are prepared in the same manner as surfaces for brush painting. For example, wood and metal surfaces are cleaned of dirt, grease, moisture, and in some cases, old paint; concrete is allowed to weather in order to neutralize the alkalis present in the cement.

b. Accessories such as ladders, scaffolds, lights, and dropcloths are used for both brush and spray painting. Usually, more protection is needed for border areas when spray painting than is needed for brush painting. Some of these protective measures include:

Covering shrubbery, walks, floors, windows, and doors.

Placing a cover over parts of machinery, trucks, and tractors that do not need painting with the immediate coat.

Protecting with a cover or not painting when wind may move the spray to adjoining objects.

c. Spray painting may require the use of a respirator and a removal of fumes from the area where the painting is being done. Safety precautions should be observed when painting around fires. Smoking is dangerous when painting.

d. Mixing, thinning, and straining are very important steps to observe when using a spray gun. The steps are:

When mixing paint for brush or spray painting, pour off the oil or thin material into another can, stir the pigment, and remix it with the thin material. The cup or tank is not used as a mixing container.

The adding of a thinner to paint will prevent it from running, but it also reduces the thickness of the paint film.

Paints should be strained through a fine wire screen or an old nylon hose before spraying. Even though a wire screen is used over the bottom of the fluid tube, it is still necessary to strain the paint.

e. Adjust the gun as follows:

Open spreader adjustment valve.
Open fluid needle screw - first thread is visible.

Check air leaks and then connect hose to cup.
Remove atomizing nozzle, press trigger until paint passes through gun.
Replace nozzle and set pressure.

15. Spraying Surfaces

Transparency No. 4

a. Distance of Gun from Surface - The gun should be held 6 to 8 inches from the surface. A good practice is to place the thumb on the nozzle (air cap) point and stretch the fingers forward to the surface. Incorrect distance causes the following problems:

If the gun is held too closely the paint is put on thickly. If the surface is vertical, the paint will sag.

If the gun is held too far away from the surface, a sandy finish and excessive dusting will result, causing an inferior finish.

Transparencies Nos. 5 and 6

b. Gun Position - The correct position to hold a spray gun is vertically to the surface. It should also be moved in a parallel line to the surface. The overlap should be about 50% of each previous lap on the surface. Several problems may develop if the gun is held improperly. The problems may include:

Uneven covering will develop if the gun is arced at each end of the stroke. Excessive overspray develops where the gun passes near the surface.

If the gun is pointed upward while painting, the pattern will be heavy at the bottom. If it is pointed downward, the pattern or coat will be heavy at the top.

The trigger should be pulled just after the stroke begins and released just before the stroke ends, otherwise the pattern may be heavy at the beginning and end of each stroke. A light pull on the trigger may cause feathering and a small pattern. This practice is desirable when a stroke is butted next to another.

c. Painting Edges and Corners - Edges and corners should be sprayed before spraying the flat surfaces. Inside corners should be sprayed by making strokes over each face of the corner surface separately. Both sides of an outside corner are painted with one stroke.

d. Slender Surfaces - The circle of a spray pattern should be just large enough to cover the surface. Excessive over-spray will result if the pattern is too large.

e. Round Surfaces - Round work is sprayed by following the curve with the pattern. The strokes should conform with the round surface.

16. Cleaning the Spray Gun

a. It is necessary to use a good solvent, such as paint thinner, painter's naphtha, or benzene to thoroughly clean the painting equipment.

b. Spray gun cleaning steps include:

Clean the cup or tank with a solvent.

Add solvent to the clean container and blow it through the gun with compressed air.

Take the nozzle apart and clean the parts in the solvent.

If a tank is used, run enough solvent through the hose to completely clean it of all paint.

Wipe the equipment clean and remove excess solvent.

Place the nozzle parts of the gun (still attached to the gun) in a solvent if it is idle for an hour or two. Some paints will dry within an hour or two on the nozzle.

17. Safety Precautions to Observe When Painting

a. Flammable liquids such as thinners, turpentine, and lacquers should be handled in safety containers and never used around a flame or fire. A safeguard against a fire is to have a fire extinguisher (pressurized dry chemical type) available.

b. When the ventilation is poor or when working in close quarters with the spray gun, it is a good practice to use a respirator, and maybe wear gloves or grease the hands and face to protect against fumes or vapors.

c. Painting should be done in areas free from running motors and engines, free of devices that will cause electric sparks, and free of open flames (heaters).

d. It is very important that a spray unit have an automatic switch to keep the pressure at a constant level and a safety valve. Usually not more than 50 pounds of pressure is used on the paint cup.

e. When painting large equipment such as combines and harvesters, ladders

should be checked for sound footing, and if possible the ladder should be tied to the machinery being painted. A rope or string can be used to hoist a spray gun from the floor or ground to the position for spraying. This frees both hands for climbing a ladder.

f. Due to toxic materials found in many paints, the containers should be kept closed, and discarded paint should be covered in a deep hole. Animals may lick or eat exposed toxic paint materials.

References:

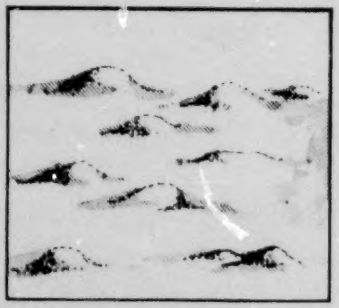
1. Phipps, Lloyd J., Mechanics in Agriculture , The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967.

2. Wakeman, T. J., Modern Agricultural Mechanics, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1977.

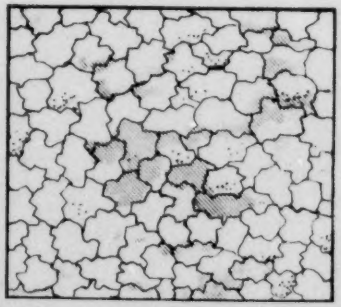
3. "Spray Painting", University of Illinois, Urbana, Illinois, 1970.

4. "Brush and Spray Gun Painting", Vocational Instructional Services, Texas A & M University, College Station, Texas, 1976.

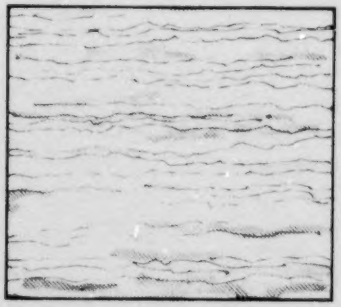
PAINT FAILURES



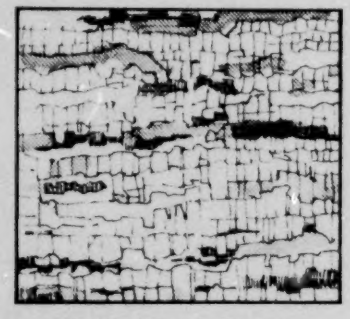
BLISTERING



CRACKING & ALLIGATORING



WRINKLING



CRACKING & SCALING

PEELING

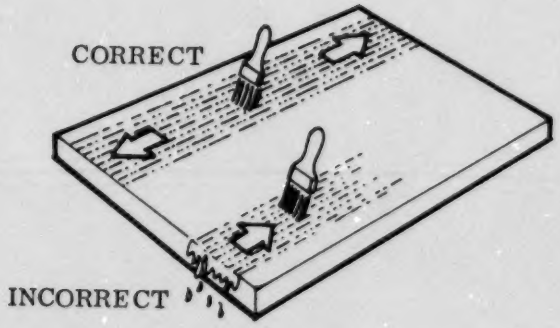
RUNNING & SAGGING

BRUSH PAINTING

Thoroughly Mix Paint

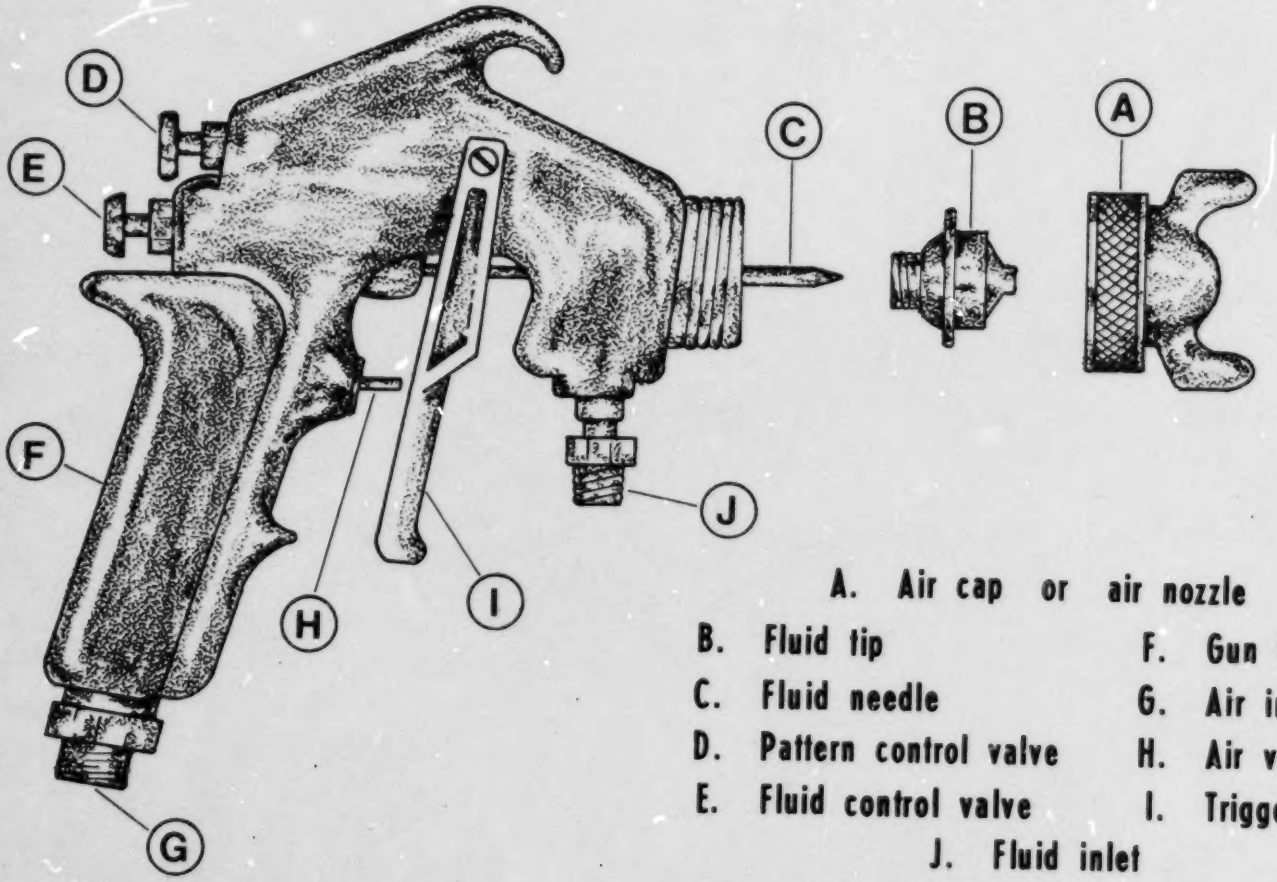
Properly Hold Brush

Dip 1/3 Length of Bristles in Paint



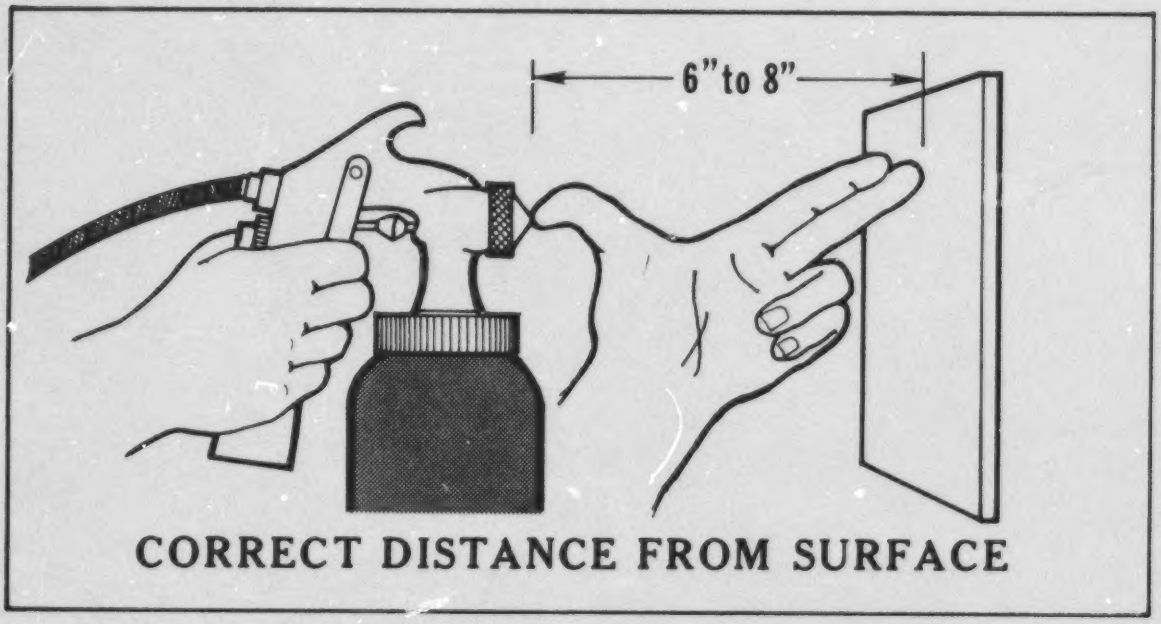
Properly Apply Paint

PARTS OF A SPRAY GUN

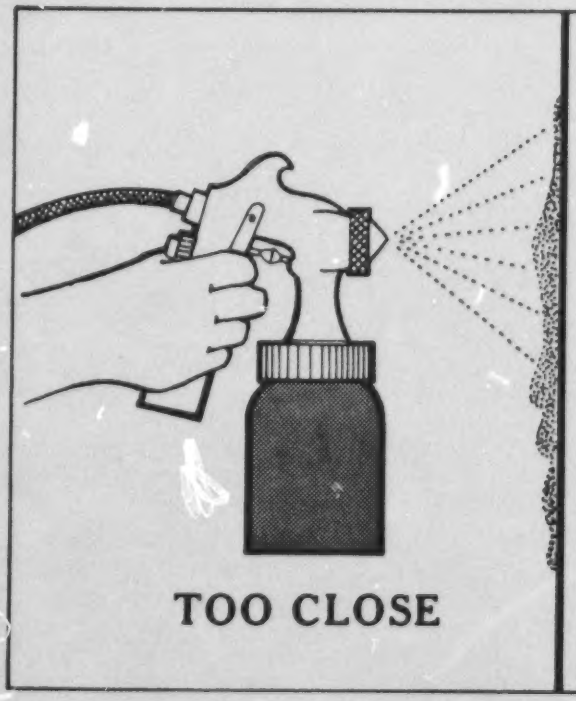


A. Air cap or air nozzle
B. Fluid tip
C. Fluid needle
D. Pattern control valve
E. Fluid control valve
F. Gun body
G. Air inlet
H. Air valve
I. Trigger
J. Fluid inlet

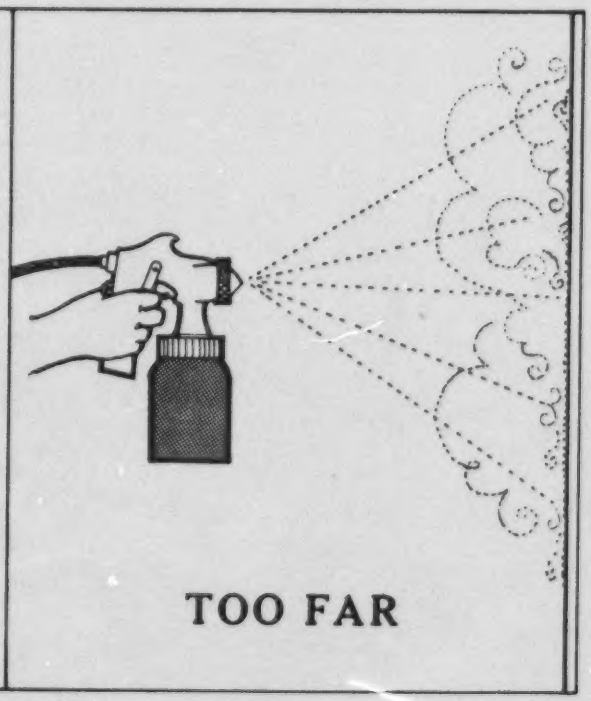
SPRAY GUN POSITION



CORRECT DISTANCE FROM SURFACE

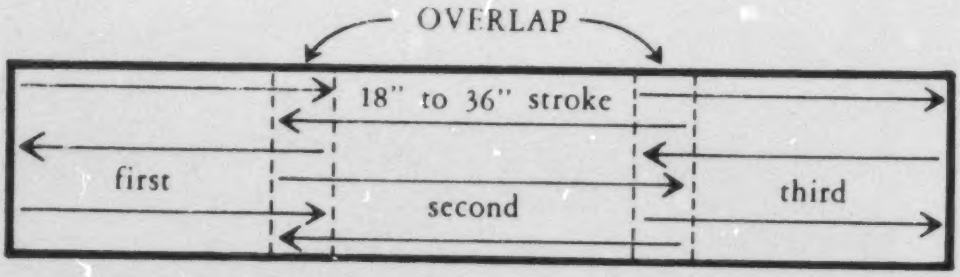


TOO CLOSE



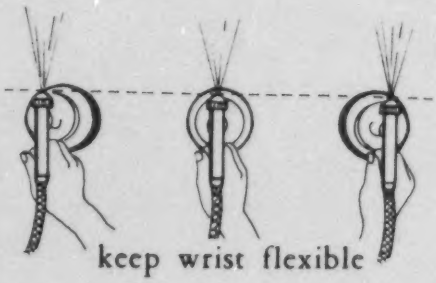
TOO FAR

USE OF SPRAY GUN



OVERLAP END OF PARALLEL STROKE

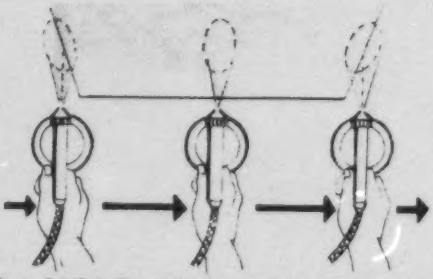
MOVE GUN IN STRAIGHT LINE



keep wrist flexible

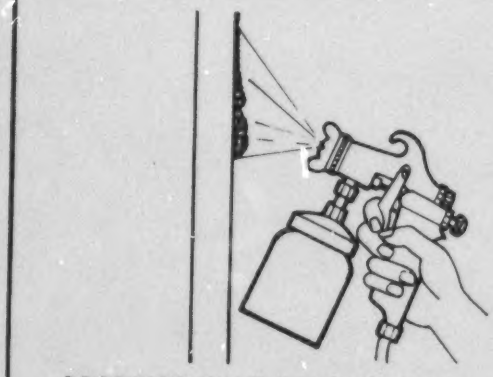
ARCING GIVES UNEVEN COATING

wrist is too stiff

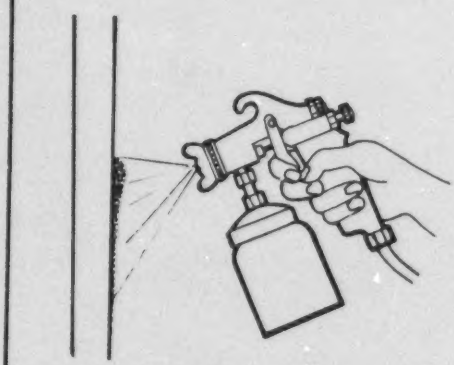


•PULL TRIGGER • HOLD TRIGGER TIGHT • RELEASE TRIGGER

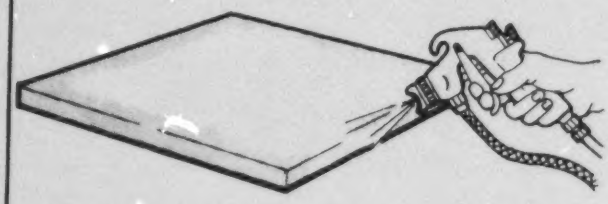
USE OF SPRAY GUN

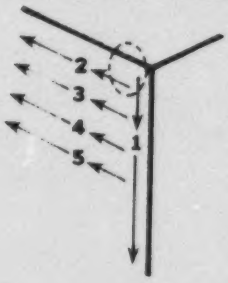


NOZZLE POINTED UPWARD

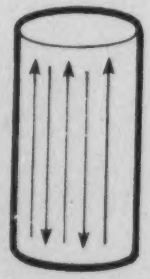


NOZZLE POINTED DOWNWARD



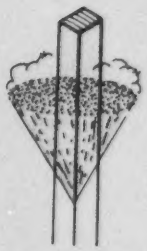


SPRAYING EDGES & CORNERS



small round work sprayed parallel

CORRECT



INCORRECT

CONSTRUCTION AND MAINTENANCE

UNIT C: Farm Water Supply and Sanitation

TOPIC 1: Skills Needed to Install Pipe and Plumbing Fixtures

1. Maintaining the Farm Water Supply

In order to avoid delays, save money, and maintain a constant supply of water to farm buildings and for livestock, the farmer should be able to make minor repairs to the farm water system. If a farmer has an extensive water system or several systems, it may be wise to obtain the necessary tools and to perform the major repairs to the water system.

Repairing Faucets and Valves

Repairs to faucets and valves are possibly the maintenance jobs most often performed by the farmer. Faucets are used at water discharge points, while valves are used to close off a part of the plumbing system. Faucets and valves are very similar, and the instructions for repairing them are the same. There are several kinds of each, but all are repaired in about the same manner.

Transparency No. 1

Mixing faucets, found on sinks, bathtubs, and showers are actually two separate units. Each unit should be repaired independently. If a faucet drips when closed, or vibrates ("sings" or "flutters") when open, it usually has a worn washer. If it leaks around the spindle when open, new packing is needed around the stem.

The following procedure may be used to replace the washer:

a. The water is shut off at the valve nearest to the faucet.
b. The faucet is disassembled in the following order:
    1. Handle
    2. Packing nut
    3. Packing
    4. Spindle
c. The screw and worn washer are removed from the spindle. A new washer is installed in the cup.
d. The seat should be examined. If it is rough, it should be refaced with a seat-dressing tool, which may be purchased from a hardware store.
e. The faucet is reassembled. To replace the packing, one should remove the handle, packing nut, and add packing, and install a new packing

washer. If a packing washer is not available, stranded graphite-asbestos wicking may be wrapped around the spindle. The packing nut is screwed tight against the wicking.

Repairing Leaks in Pipes - Leaky pipes are usually caused by corrosion or damage from freezing, machinery, or animals. Generally when corrosion exists, it is in varying degrees for the entire length of the pipe; however, an exception to this occurs where different kinds of metal are joined, such as copper and steel. There is a tendency for different kinds of metal to corrode much faster where they are joined. It is possible at times to prevent corrosion by testing the water and taking the proper precautionary measures if they are needed. The method used to repair a leaky pipe is determined by the area in which the pipe leaks and the size of the leak. Leaks may be repaired as follows:

a. Small pipe leaks - Emergency repairs can be made with a rubber patch, metal clamp, or sleeve. However, the pipe should be replaced as soon as practicable.
b. A leak at a threaded connection - This type of leak can often be stopped by unscrewing the fitting and applying a pipe joint compound. The compound, available from most plumbing supply firms, seals the joint when the fitting is screwed back together.
c. Large leaks in a pipe - There are several ways of repairing this type of leak. The old pipe can be removed and plastic pipe put in its place. (Clamps are used to hold the pipe in place.) This type of repair should not be used in the farm household. If the leak is near a joint, the damaged pipe may be cut out and a new pipe installed with the use of a union.
d. Leaks at solder joints - Due to vibration or some other reason, solder joints sometimes start leaking. These may be resoldered if they are accessible.

Repairing Leaks in Storage Tanks - Most farms have several tanks for storing water or other liquids. The life of these tanks may be prolonged by repairing the leaks. One method of repairing a leak in a tank is to use a rubber washer, brass washer, and toggle bolt. It may be necessary to drill the hole larger in the tank to insert the toggle bolt. The rubber washer, brass washer, and nut are placed on the toggle bolt in the order given. The toggle bolt is pushed through the hole, and the nut is tightened until the rubber washer is compressed against the tank. This repair will postpone buying a new one, but the tank will eventually have to be replaced.

2. Repairing Water Closets

There is some variation in the design of flush toilets, but they are enough alike that one should be able to repair them by following these instructions.

Transparency No. 2

The flush valve, intake (float) valve, and float ball are generally the parts on a water closet that need repairing. Instructions for repairing each are given.

Repairing the Flush Valve - A leaky flush valve is usually caused by the decomposition of the rubber ball. It gets soft and fails to seat properly. Other parts that may cause the flush valve to leak are the trip lever, connecting rod, or lift wire. If they cannot be repaired, they should be replaced.

To replace the rubber ball, stop the flow of water by tieing the float or propping it up with a piece of wood. The lift wire is screwed out of the rubber ball and screwed into the new one. This can be accomplished without removing the tank ball guide from the overflow pipe.

Repairing the Intake Valve - A worn plunger washer in the supply valve will cause this valve to leak. If the washer is not causing the leak, the float-valve assembly should be replaced. The procedure for replacing the washer is as follows:

a. The water is shut off, and the tank is drained.
b. The two thumbscrews that hold the levers are unscrewed, and the levers are pushed out.
c. The plunger is lifted out, and the cup on the bottom is unscrewed. A new washer is inserted.
d. The washer seat should be refaced if needed.

If the float ball is leaking or fails to rise to the proper position (correct water level is about one inch below the top of the overflow tube), the ball should be repaired or replaced.

Water Closet Bowl Removal - If the water closet bowl leaks, it may be necessary to remove it to repair the leak. The procedure is as follows:

a. The water is shut off.
b. The tank and bowl are emptied.
c. The water pipes are disconnected from the tank.
d. If it is a two-piece unit, the water bowl is disconnected from the tank.
e. The seat and cover are removed.
f. The bolt covers are removed, and the bolt holding the bowl to the floor flange is removed.
g. The bowl is repaired.
h. The tank is installed, and the water pipes are connected.
i. The bowl is checked for leaks by flushing a few times.
j. The seat and cover are installed.

3. Clearing Clogged Drains and Traps

Drains become clogged by objects falling into them or by an accumulation of dirt and other matter, and they should be cleaned periodically rather than waiting until they are clogged. Periodic cleanings are much easier.

If a fixture trap is clogged, usually the trap must be removed and cleaned to unstop the drain. If a drain pipe is clogged, there are several methods that may be used to unclog the drain:

a. A plunger, often called a plumber's friend, can be used successfully sometimes to unclog drains.

b. Cleanout Augers - Flexible cables are often used to clear obstructions in drain pipes. Some plumbers have power driven augers, and it may be necessary to secure their services if the drain is closed by root growth. If it becomes necessary to use a root saw, the drain should be eventually relayed.

c. Water pressure from a hose may break up an obstruction or force an object through the pipe. If this method is used, the hose should be inserted well into the pipe, and rags should be wrapped around the hose where it enters the pipe to minimize a backward flow of water.

d. Chemical cleaners are an effective means of loosening grease and soap from pipes; however, they should not be used in pipes that are completely stopped up. They must be brought in direct contact with the stoppage to be effective. After chemicals are used, the pipe should be flushed with cold water.

4. Maintaining Water Pumps

The two most common water systems found on farms are the gravity flow system and the pressure system. Each system is discussed separately.

Gravity Flow System - If the gravity system is used, a pump and storage facility must be maintained to provide an adequate water supply. The maintenance problems usually connected with a gravity flow system are the repairing of leaks and the maintaining of an adequate flow of water. Observing the daily water consumption on the farm will assist the farmer in detecting leaks. If an abnormally large amount of water is used during a short period, or if there has been a considerable increase in water consumption without an apparent reason for the increase, there is a possibility that the system is leaking. Underground leaks are difficult to detect. If after walking along the routes of the underground pipes, the farmer has not detected a leak, indicated by a wet or damp spot, a part of the water system should be turned off to determine the area of greatest consumption. If the area of the leak can be determined, all connections should be checked for leaks. If the leak is still undetected, it may be necessary to dig up some of the pipe.

Since the maintenance problems of wells and pumps are similar, regardless of the kind of water system, pump and well maintenance is discussed under the pressure system.

Pressure System - Troubles with a pressure system are more difficult to determine because of the automatic controls and safety devices.

The following list of possible problems shows what one might encounter in maintaining a well and pressure system and the areas that should be checked to eliminate the problem:

a. The Pump Fails to Deliver Water
   1. Air leak in suction pipe
   2. Water level below the end of the suction pipe
   3. Pump lost prime
   4. Stuck foot valve
   5. Plugged suction
   6. Dry well
   7. Plugged jet
   8. Cracked cylinder
   9. Worn leathers (reciprocating pump)
   10. Worn valve on jet pump
   11. Broken plunger rod

b. Pump Fails to Deliver a Normal Amount of Water
   1. Pipe valve leaking
   2. Cracked cylinder
   3. Air in suction pipe
   4. Belt to motor is too loose
   5. Low voltage
   6. Suction pipe too small
   7. Improper setting on pressure regulator

c. Pump Stops and Starts Often
   1. Not enough air in pressure tank
   2. Leaky foot valve
   3. Leak in plumbing
   4. Tank too small
   5. Air pump out of order

d. Air Spurts from Faucets
   1. Too much air in tank

e. Pump Motor Fails to Run
   1. Power off
   2. Broken power line
   3. Blown fuse
   4. Circuit breaker open
   5. Burned motor
   6. Reset fuse blown
   7. Malfunctioning motor switch

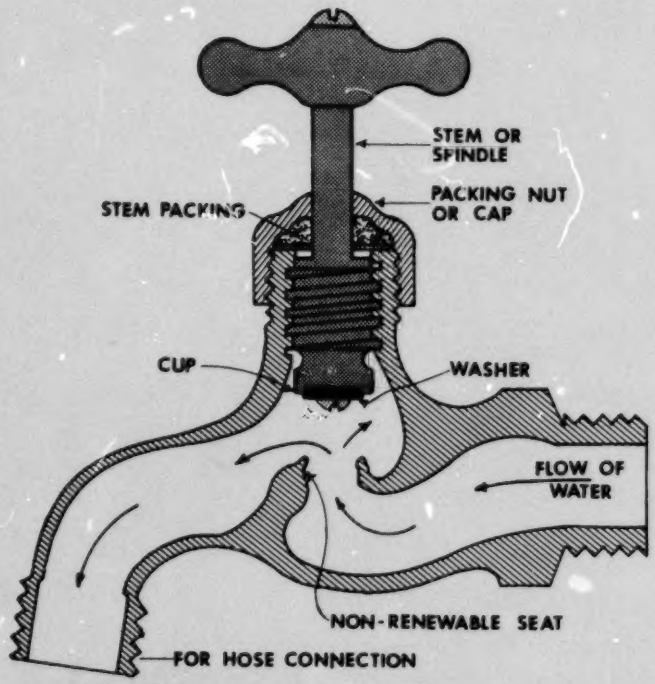
References:

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967.

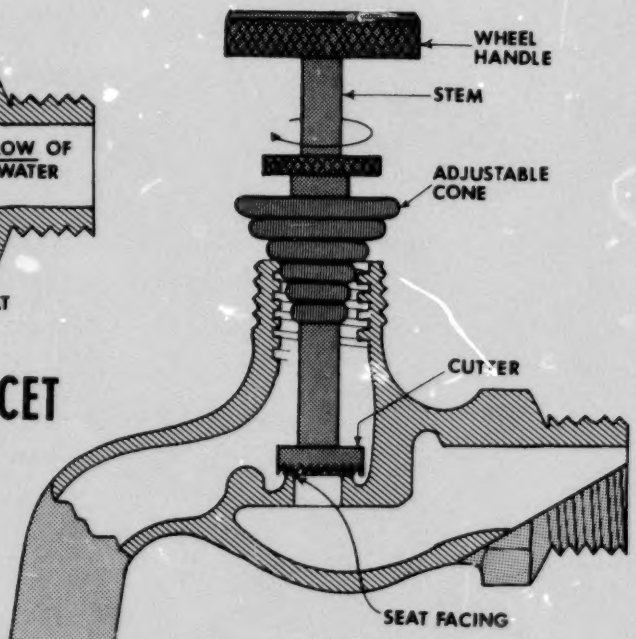
2. Wakeman, T. J., Modern Agricultural Mechanics, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1977.

3. Wright, Forrest B., Rural Water Supply and Sanitation, John Wiley and Sons, Inc., New York, New York, 1956.

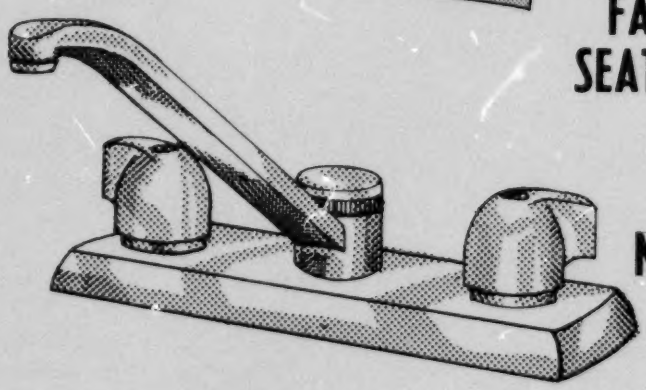
FAUCET & SEAT DRESSER



COMPRESSION TYPE FAUCET

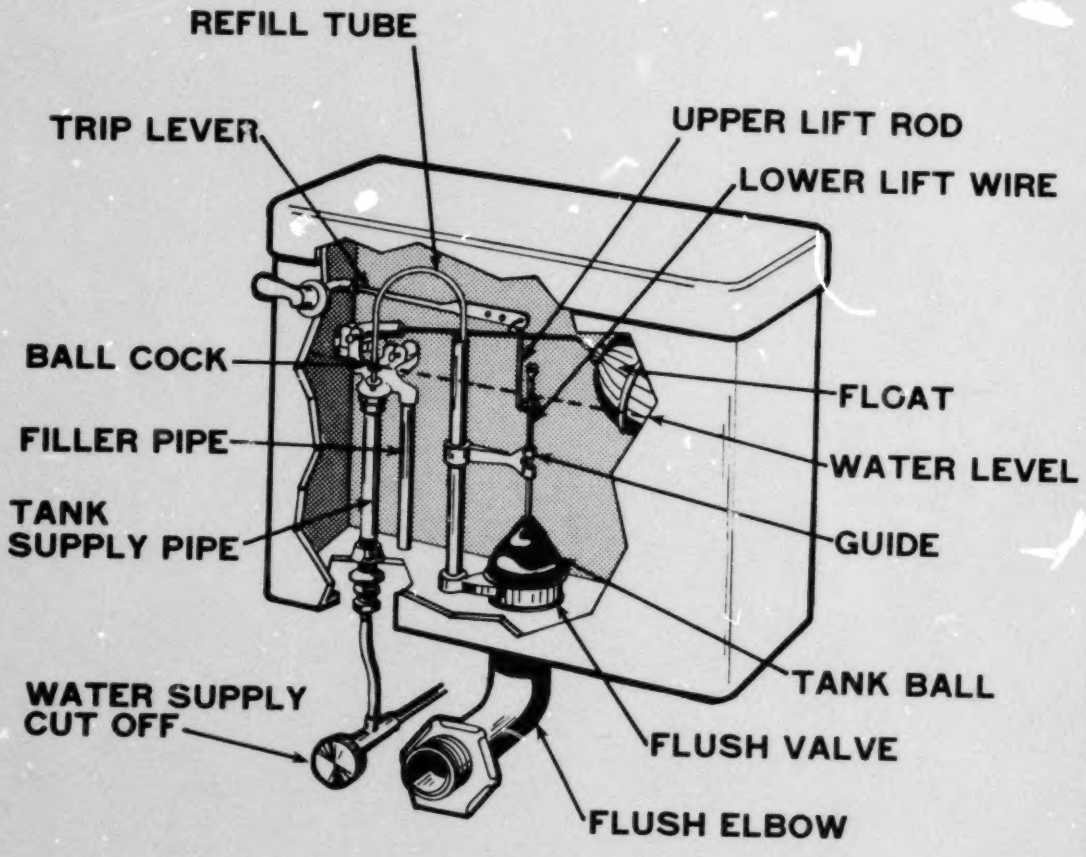


FAUCET SHOWING SEAT BEING REFACED



MIXING FAUCET

WATER CLOSET



CONSTRUCTION AND MAINTENANCE

Unit C: Farm Water Supply and Sanitation

Topic 2: Skills Needed to Maintain Farm and Home Water System

Suggested Procedure and Activities: Students should be given the opportunity to perform the skills listed in this topic.

1. Reading Blueprints and Recognizing Plumbing Symbols

Before installing plumbing (considered to be any part of the water or waste disposal system) on the farm, or in a farm structure or dwelling, the farmer should have a detailed set of plans for the proposed plumbing. The preparation of detailed plans requires a lot of planning and forethought on the part of the farmer, as well as possibly securing the assistance of a professional plumber. In planning an adequate water and waste disposal system, there are several factors that must be considered. Some of these factors are source and availability of power (generally electricity), amount of water or other utilities needed at different locations, distance from source to outlets, pump capacity, storage capacity, the possibility of future expansion (it is expensive to install larger fittings and other plumbing when remodeling), electrical protection, size and kind of pipe and fixtures available, and cost.

There are certain plumbing symbols which make it easier to prepare drawings and blueprints of a plumbing system. In order to plan a farm water system and to read blueprints, a farmer must be able to recognize these symbols. Some of the symbols are shown in the following transparencies.

Transparencies Nos. 1, 2, 3, 4a & 4b

Blueprints or drawings are necessary to determine the amount of pipe and fixtures needed for a plumbing job. They are also used as installation plans and help to determine costs. Plumbing drawings may be of two kinds, single line or double line. Transparency No. 5 shows examples of each.

Transparency No. 5

2. Selecting Pipe

The farmer has several choices when selecting the pipe to use for a given plumbing job. The different kinds of pipe, based on the materials used in their construction, are galvanized steel, black steel, copper, brass, cast iron,

and plastic. All of the pipe listed above is not necessarily recommended for all plumbing jobs. General information about each kind of pipe is given in the following paragraphs.

Galvanized Pipe - More galvanized pipe is used for plumbing than any other kind. It is very durable and will last thirty to forty years under normal conditions. Galvanized pipe corrodes rather easily in alkaline and acid water and will burst if frozen. It can be purchased in three different weights: standard, extra strong, and double extra strong. The outside diameter of each weight is the same; however, the metal of the extra strong and double extra strong is thicker. The extra strong and double extra strong are usually connected by flanges or welded; therefore, these are not usually used on farm plumbing jobs. Standard galvanized pipe can be purchased in a wide range of sizes. One-eighth inch is the smallest size, while twelve inches is the largest. Pipe size is determined by the diameter of the pipe opening or inside pipe size.

Black Steel Pipe - Black steel pipe may be purchased in the same sizes as the galvanized pipe. Because it corrodes so quickly, black steel pipe is not used on most plumbing jobs. It may be used as gas lines in areas where the pipe is protected from the weather and soil. It is the most economical pipe to buy.

Brass and Copper Pipe - Brass and copper pipes are interchangeable, but more copper is used than brass. There are two kinds of copper tubing, type K, a heavy duty pipe, and type L, the standard copper pipe. Copper tubing is resistant to corrosion and has a life expectancy of forty to 100 years. It can freeze several times before it will burst. Copper tubing is particularly useful in areas where rigid pipes are difficult to lay. It may be purchased in twenty-five foot coils, and there are nine outside dimension sizes from 1/8" to 1".

Plastic Pipe - There has been an increase in the amount of plastic pipe being used on farms. One of the reasons for this increase is the improvement in the quality of the pipe. Plastic pipe is easily laid and does not require any special tools. However, it is easily punctured, loses its strength under prolonged exposure to weather, and should not be used for hot water runs. Most city plumbing ordinances prohibit the use of plastic pipe inside of a home. It is available as rigid plastic pipe in 10-foot lengths and flexible plastic pipe in 60-foot coils. Several grades are available. If the pipe is to be used several years, the most economical plastic pipe to purchase is the best quality. Both fibre and plastic pipes are available in four-inch sizes and ten-foot lengths. There is also the perforated type used for septic tank drainage and subsurface field drainage. The solid type is used for house - to sewer, downspout drainage and on non-pressure uses. Pipe are joined by driving them into a self sealing coupling.

Cast Iron Pipe - Cast iron pipe is used for drains and vents. The pipe ranges in size from two to twelve inches in diameter. The pipe may be purchased in five-foot lengths and in both single and double hubs (explained later). Cast iron pipe does not corrode and will last indefinitely.

After one has reviewed the advantages and disadvantages of the different kinds of pipe and the recommended uses of certain pipe, the following factors should be considered in determining the kind of pipe to use on a given job:

a. Mineral or chemical content of water;

b. Resistance to corrosion;

c. Life expectancy;

d. Recommended pressure;

e. Resistance to deposits;

f. The use of the pipe;

g. Lengths available; and

h. Cost.

The factors to consider in determining the size of pipe to purchase are as follows:

a. Amount of water needed at outlet;

b. Expected increase in water use at outlet; and

c. Distance water must travel from source to outlet.

3. Pipe Fittings

A part of any plumbing skill will be in developing the ability to recognize the different kinds of pipe fittings. Fittings can be purchased in the same sizes as pipe. Some fittings that may be used with different kinds of pipe are shown in the following transparencies.

Transparencies Nos. 6, 7, and 8

The plastic fittings shown in Transparency No. 8 are used with a clamp. There are also plastic fittings that may be glued to the pipe.

Fittings make pipe much easier to install and are used in the following ways:

a. To connect pipe;

b. To change the direction of pipe;

c. To reduce the size of pipe; and

d. To plug pipes.

Fittings have the same inside dimension as the pipe it is used on and are designated by size of pipe they fit. For example, one-inch tees fit one-inch pipe.

Transparency No. 9a & 9b

There are several kinds of valves used in plumbing. The most common are the safety, check, hydrant, stop and waste, gate, and globe. Safety valves are used on hot water heaters to release water and temperature. When the pressure on the spring is exceeded by the pressure under the seat, the seat is lifted, and water and air flow through.

Check valves are used to prevent a backflow of water. They are automatic and open and close with the direction of flow.

Globe valves are used to cut off the flow of water or to drain the water line. It should be installed with the pressure under the valve seat. Otherwise, it will leak. The gate valve is used the same way as a globe valve. It has an advantage over the globe valve: it will not restrict the flow of water.

There are two types of stop and waste valves, globe and ground key. They are used to shut off the pressure and drain the line.

A hydrant valve is similar to a stop and waste valve. When the water is turned off, the pipe is drained from the surface back to the valve. This prevents freezing in cold weather.

4. Plumbing Tools

In order to install pipe and plumbing, certain tools are needed. The following transparency shows most of the tools needed to install plumbing.

Transparencies Nos. 10a, 10b, & 10c

Pipe Vise - The farmer may use a combination pipe and machinist's vise or a regular pipe vise. Three different kinds are shown in the transparency.

Pipe Cutter - A small amount of pipe may be cut with a hacksaw; however, pipe cutters require less effort and generally make a straighter and smoother cut. Galvanized pipe cutters and tube cutters are available.

Stocks and Dies - Several brands are available, and there is some variation in quality among the different brands.

Pipe Wrenches - Several kinds and sizes of wrenches are available. Usually two wrenches are needed to tighten and loosen pipes. The farmer should select wrenches that are large enough for the job.

Burring Reamer - A burr is made on the end of a pipe while it is being cut. A reamer should be used to remove the burr. Two types of reamers are shown in the transparency. One is used on galvanized pipe, while the other is for copper tubing. The copper tubing reamer is a part of the tube cutter.

Flare Tool - The flare tool is used to form a flare on the ends of copper tubing when flare type fittings are used.

5. Measuring, Marking, Cutting, and Reaming Pipe

To accurately measure the length of a pipe, one must know the distance that the pipe screws into the fitting and the distance taken up by the fitting. Different size pipe and fittings require different distances. Charts are available that give the distances taken up by fittings and the distance pipe is screwed into fittings. Transparency No. 4 shows the area to measure to determine the length of several fittings. After using various fittings on plumbing jobs several times, one will learn the distances taken up by each size fitting.

Transparency No. 11

Measuring Pipe: There are three methods of measuring pipe:

a. The distance between the fittings is measured, and an allowance is made for the thread that screws into the fitting. One-half inch should be allowed for the fitting if one-inch pipe is used, and three-fourths of an inch of thread is allowed for pipe 1¼ inches to two inches in diameter. This method should not be used when accurate measurements are needed.

b. A more accurate method for measuring pipe is to measure the distance from the center of one pipe to the other pipe (as shown in Transparency 11, Figure B) and subtract the diameter of the pipe for each thread. A farmer using one-inch pipe, for example, would subtract two inches from the length of the pipe, one inch for each end of the pipe.

c. When pipe larger than 1¼ inches in diameter is used, the distance to the center of the pipe is measured, and the fittings are measured from the center of the pipe to the back of the thread of the fitting. See Transparency No. 11, Figure C.

Marking Pipe - The length of the pipe may be measured with a ruler or tape measure, and the pipe should be marked with the edge of a three-cornered file.

Cutting Pipe - To prepare pipe for cutting, the farmer should fasten the pipe in a pipe vise with the mark made by the file approximately four inches in front of the vise. The procedure for cutting the pipe is as follows:

a. The opened pipe cutter is slipped over the pipe, and the cutter handle is turned until the wheels are snug against the pipe at the mark.

b. A few drops of oil (cutting oil) are placed on the mark.

c. The pipe cutter is turned around the pipe, and the screw handle is turned one-fourth turn each revolution of the cutter until the pipe is cut off.

d. The reamer is used to remove the burr that is left on the inside of the pipe after it is cut. If the burr is left in the pipe, it will restrict the flow of water.

6. Threading Galvanized and Black Pipe

A pipe thread is tapered so that it will make a tight joint when the fitting is screwed onto the pipe. In order for the joint to be tight, the thread must be cut properly. The procedure for cutting a pipe thread is as follows:

a. The pipe is cleaned of dirt, rust, and other materials.

b. The rough edges are removed from the end of the pipe to be threaded.

c. The pipe is secured in a vise.

d. Cutting oil or lard oil is applied to the die.

e. Inward pressure is applied to the die as it is turned on the pipe. After the die becomes engaged on the pipe, the inward pressure should be discontinued.

f. The pipe should be oiled frequently ahead of the die.

g. The threading is continued until one thread is showing outside of the die. More threads should be showing on large pipe. The die should never be turned backwards or back and forth. This will ruin the threads.

h. The die is backed off of the threads carefully. If the die should catch, it should be turned forward again to dislodge the metal chips.

i. The pipe is cleaned of oil and removed from the vise. The die also should be cleaned.

7. Flaring Copper Tubing

When flare type fittings are used, it is necessary to make a flare at the ends of the tubing. The procedure for flaring the tubing is as follows:

a. A sleeve nut is slipped on the section of copper tubing.

b. The burr, if present, should be removed from the end of the tubing.

c. The tubing is wrapped with cloth or leather (to prevent marring) and placed in a vise.

d. A few drops of oil are applied to the flaring tool.

e. The flaring tool is placed over the end of the tubing, and the tubing is placed flush with the surface of the tool.

f. The flaring tool is screwed into the end of the tubing to make a flare.

g. The flare tool is removed, and the sleeve nut is placed in position. The flare end is now ready to be placed on the fitting.

8. Assembling Tubing with Solder Fittings

A gas soldering or brazing torch is recommended for soldering fittings. Also, a flux, recommended for use with the solder, should be used. The following is a step procedure for assembling copper pipe with solder fittings:

a. The copper tubing is cut square, and the burr is removed.

b. The outside area of the tubing that will be covered with the fitting is cleaned thoroughly.

c. The inside of the fitting is cleaned thoroughly.

d. Flux is applied to the cleaned portion of the tube.

e. The fitting is placed on the tubing, pushed against the shoulder of the fitting, and is turned several times to distribute the flux.

f. Heat is applied until the flux boils and the copper will melt solder.

g. Solder is applied until it appears completely around the edge of the fitting. Because of the close fit of the fitting and the pipe, the solder will flow by capillary action throughout the joint when the joint is properly heated. This action is in every direction -- up, down, or sideways. The flame should be removed from the joint as quick as the joint is filled with solder. Excessive heat will cause the solder to boil out of the joint.

h. The joint is allowed to cool.

9. Measuring, Cutting, and Assembling Cast Iron Pipe

This type of pipe is often referred to as cast iron soil pipe because it is used for drains and vents and is in contact with the soil.

When measuring cast iron pipe, an allowance should be made for the hub. Different size pipes require different allowances. After the pipe has been measured, a mark, which will indicate the area to cut, should be made with chalk around the pipe.

When ordering cast iron pipe, the farmer should order enough double hub pipe to make all of the cuts from. Cast iron pipe may be cut by three methods: a cast iron pipe cutter, a hacksaw, or a chisel. An explanation of cutting cast iron pipe with a hacksaw and chisel is given in the following paragraphs.

Transparency No. 12

If a hacksaw is used, a 1/16-inch deep cut is made around the pipe. After the cut is made, the pipe is tapped with a hammer until it breaks. The hacksaw should be used only on service weight pipe. A cutter or a cold chisel should be used on heavier pipe.

When a cold chisel is used to cut the extra heavy weight pipe, the farmer should place the pipe on a board as shown in the transparency. A file is used to mark the pipe, and a chisel is used to made a light cut around the pipe. The pipe is rolled on the board as it is cut.

There are two kinds of joints that are used in connecting cast iron pipe. These are vertical and horizontal. The procedure to follow in making a vertical joint is as follows:

a. The hub is placed in an upright position.

b. The pipe and joint are cleaned, and the spigot end is placed into the hub its full depth.

c. Oakum, a form of rope, is wrapped around the pipe and packed with the yarning iron. The joint is filled within 3/4 inch from the top of the hub. The oakum must be packed tightly and evenly to make a waterproof joint.

d. Molten lead is poured into and around the joint. Enough lead should be picked up in the ladle to fill the joint in one pouring.

e. The lead is allowed to cool, and the joint is calked (packed) to made it watertight. A hammer and calking iron are used for this.

The procedure for assembling a horizontal joint is the same, except an asbestos joint runner is used to pour the lead in the hub.

10. Sewage Disposal System

Plans for the sewage disposal system should be developed at the same time as the water system because an adequate sewage disposal system is necessary to safeguard health and prevent disease.

Sewage passes through three stages before it becomes harmless: sedimentation, decomposition, and purification. The solids are separated by the liquids in the sedimentation stage, while two types of bacterial action (aerobic and anaerobic decomposition) cause their decomposition. These bacteria will usually establish themselves in a septic tank; however, they may be purchased commercially and placed in the septic tank. The purification of sewage is accomplished as the liquid is aerated through the soil in the disposal field.

The most inexpensive method of sewage disposal for the farm home is a septic tank with an underground disposal system. However, in some areas it may not be possible to use this system. Heavy, impervious soil or a high water table will prevent the use of a septic tank. Before installing this type of sewage disposal, one should run a percolation test to determine if a septic tank and underground disposal system will function properly.

Transparency No. 13

The three parts of a sewage system are the sewer line from the house to the septic tank, septic tank, and final disposal system. Each will be discussed separately:

Sewer Line from the House to the Septic Tank - The length of the sewer line to the septic tank will be determined by the slope of the ground, location of house and well, and the disposal field. All sewer lines should be located to prevent contamination of the well by sewage.

The drain line should be laid in a straight line and at a uniform grade. The grade of the drain is determined by the size of the line, but not less than two feet per 100 feet of line is recommended for four-inch drain pipe. Less drop may be used on larger pipe. The pipe should be laid on firm soil.

Septic Tank - The septic tank can be purchased, or it may be constructed on the site. The size of the septic tank should be determined by the number of people in the family plus others that may be expected to use the system. It should be large enough to hold the sewage for three days. A daily allowance of forty gallons per person is usually made. The septic tank should be located down hill from the home and no closer than thirty feet.

The contents of a septic tank are composed of scum, liquid, and sludge. Grease and lighter solids rise to the top to form scum, and the heavier solids sink to the bottom. Liquid remains in between. The outlet on the septic tank is constructed so as to prevent solids from leaving the tank.

Final Disposal System - Since only liquid passes through the outlet line, it is not easily clogged; nevertheless, a grade of two feet for 100 feet should be used. This will increase its capacity and decrease the possibility of freezing.

The size of the disposal area is very important and is determined by the capacity of soil to absorb liquid, size of the disposal system, amount of liquid to be disposed, and size of trench where pipes are laid. There are several ways of running disposal lines, and they may be of cast iron, vitrified clay cement, or fiber tile. Some systems have the disposal lines running from a distribution box, while others have the lines running directly from the septic tank. Regardless of the layout of the disposal tile, one should have at least two runs of tile equal in length. The runs should not exceed 100 feet in distance.

The grease trap, which is connected to the kitchen sink and is another part of the waste disposal system, may be connected to the septic tank, or it may bypass the septic tank and go directly to the disposal lines.

Some farms need a liquid manure disposal system. If the fertility of the manure is utilized, a large septic tank can be built for this purpose. A mobile, liquid manure spreader will be needed to distribute the manure. Some farmers use lagoons, large ponds, to dispose of manure.

References:

1. Wright, Forrest B., Rural Water Supply and Sanitation, John Wiley and Sons, Inc., New York, New York, 1956.

2. Phipps, Lloyd Jr., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967.

3. "Planning for an Individual Water System", American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1973.

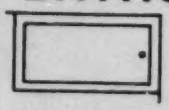
PLUMBING SYMBOLS

WATER CLOSETS

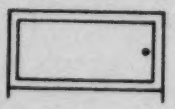
LOW TANK

NO TANK
(FLUSH VALVE)

BATHS



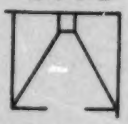
CORNER



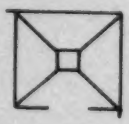
RECESSED

ANGLE TUB

SHOWERS

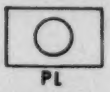


SHOWER
STALLS



SHOWER HEAD

LAVATORIES



PEDESTAL

WALL

CORNER

HOT WATER

TANK

HEATER

METER

GAS RANGE

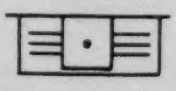
OUTLETS

GAS

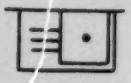
PLUMBING SYMBOLS

SINKS

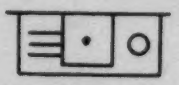
Plain Kitchen



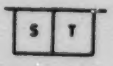
Kitchen, R&L Drain Board



Kitchen, L.H. Drain Board

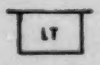


Combined Sink & Dishwasher



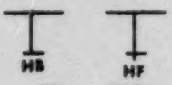
Combined Sink & Laundry Tray

Service



Laundry Tray

Hose Rack



Hose Bibs or Faucet

WASHING MACHINES

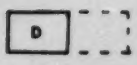
Wringer Type

Automatic

DRYERS

Centrifugal

Cabinet

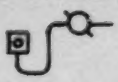


Rack

DRAINAGE SYMBOLS

Drain

Garage Drains



Floor Drain, with Backwater Valve

Lamp Hole Drain

Leader Drain

Dry Well

Receiving Basin

Yard Drain Inlet

PLUMBING SYMBOLS

PLUMBING

SOIL, WASTE OR LEADER (ABOVE GRADE) .....

SOIL, WASTE OR LEADER (BELOW GRADE) .....

VENT .....

COLD WATER .....

HOT WATER .....

HOT WATER RETURN .....

FIRE LINE ..... F F

GAS ..... G G

ACID WASTE ..... ACID

DRINKING WATER FLOW .....

DRINKING WATER RETURN .....

VACUUM CLEANING ..... V V

COMPRESSED AIR ..... A

SPRINKLERS

MAIN SUPPLIES ..... S

BRANCH AND HEAD .....

DRAIN ..... S S

PNEUMATIC TUBES

TUBE RUNS .....

DRAINAGE

SEWER-CAST IRON ..... S-CI

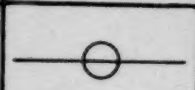
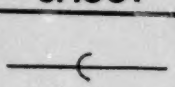
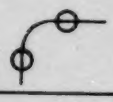
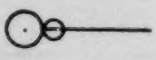
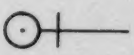
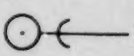
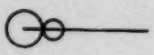
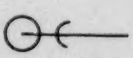
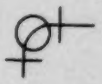
SEWER-CLAY TILE, BELL & SPIGOT ..... S-CT

DRAIN-CLAY TILE, BELL & SPIGOT .....

DRAIN-OPEN TILE OR AGRICULTURAL TILE .....

PLUMBING SYMBOLS

PIPE FITTINGS

FITTING	SOLDERED	SCREWED	BELL AND SPIGOT
JOINT			
ELBOW-90°			
ELBOW-45°			
ELBOW-TURNED UP			
ELBOW-TURNED DOWN			
ELBOW-LONG RADIUS			
SIDE OUTLET ELBOW OUTLET UP			
SIDE OUTLET ELBOW OUTLET DOWN			
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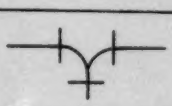
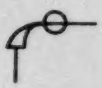
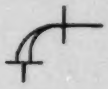
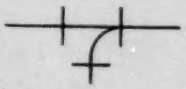
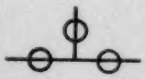
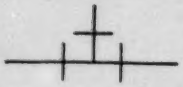
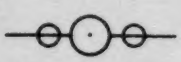
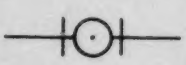
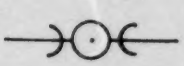
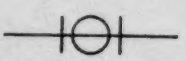
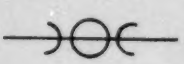
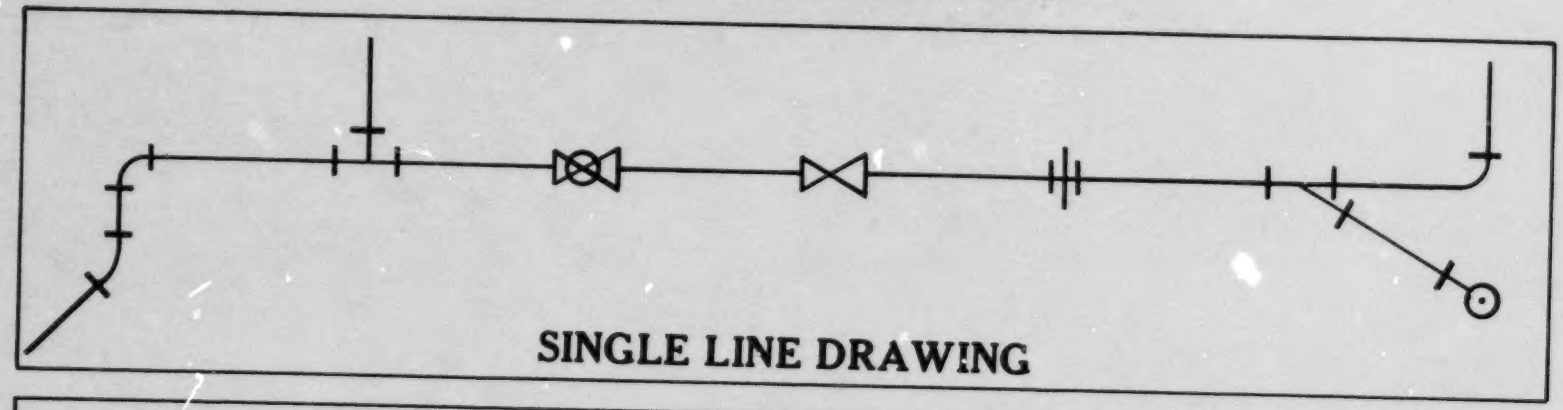
DOUBLE BRANCH ELBOW			

PLUMBING SYMBOLS

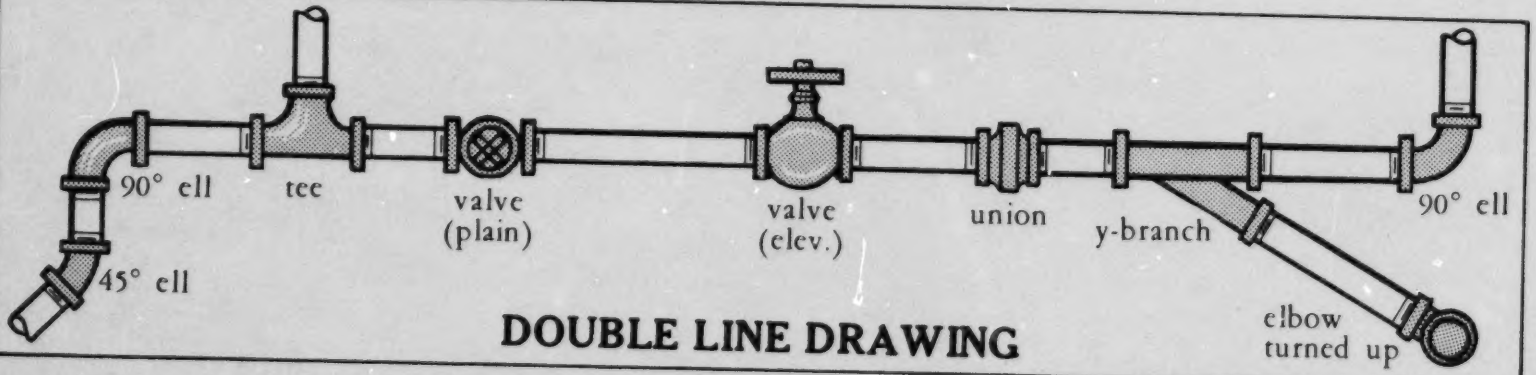
PIPE FITTINGS (cont.)

FITTING	SOLDERED	SCREWED	BELL AND SPIGOT
REDUCING ELBOW			
SINGLE SWEEP TEE			
DOUBLE SWEEP TEE			
TEE			
TEE-OUTLET UP			
TEE-OUTLET DOWN			
SIDE OUTLET TEE OUTLET UP			
SIDE OUTLET TEE OUTLET DOWN			
CROSS			

EXAMPLES OF SINGLE AND DOUBLE LINE DRAWINGS

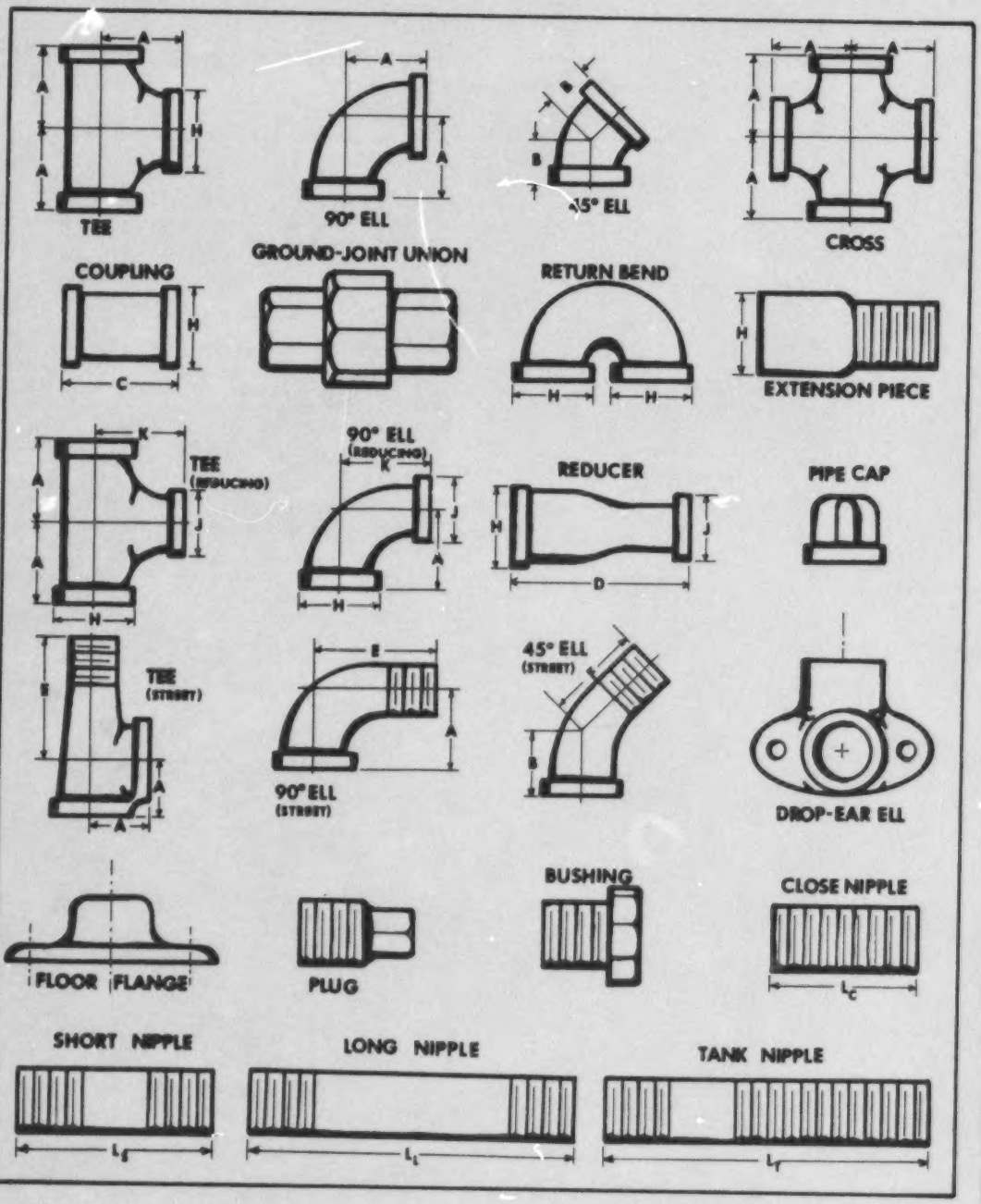


SINGLE LINE DRAWING

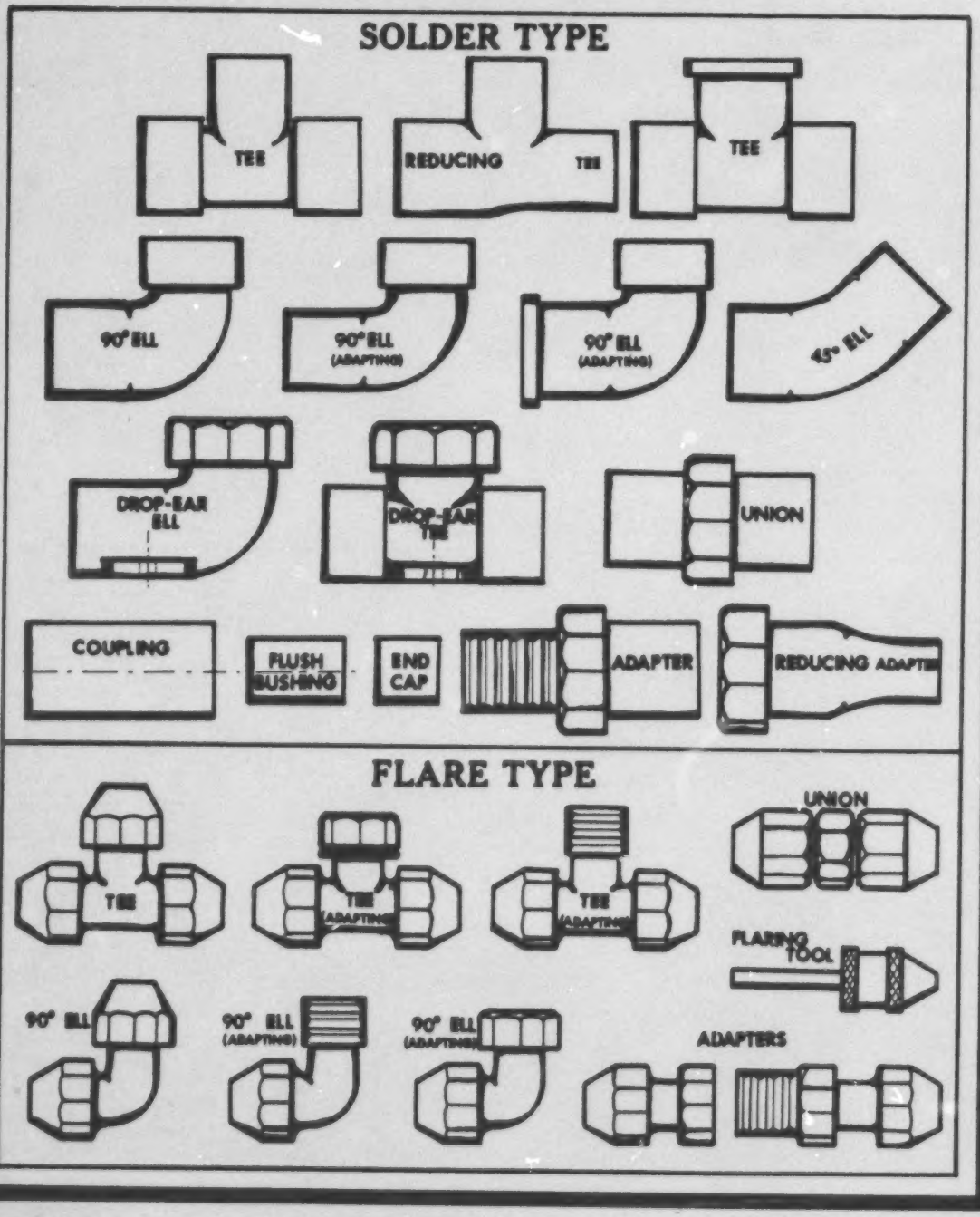


DOUBLE LINE DRAWING

STANDARD PIPE FITTINGS

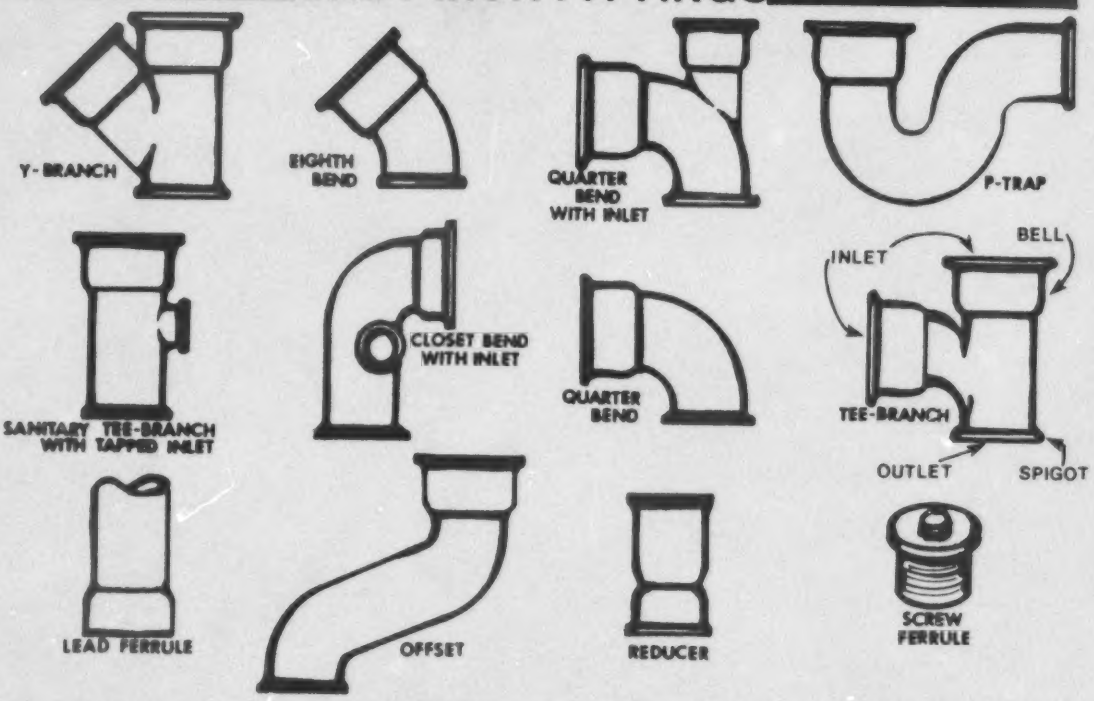


COPPER PIPE FITTINGS

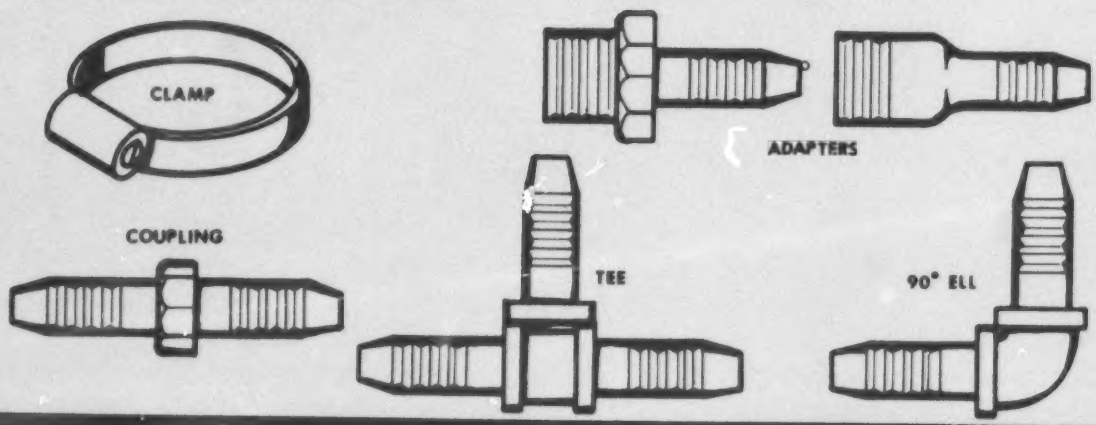


KINDS OF PIPE FITTINGS

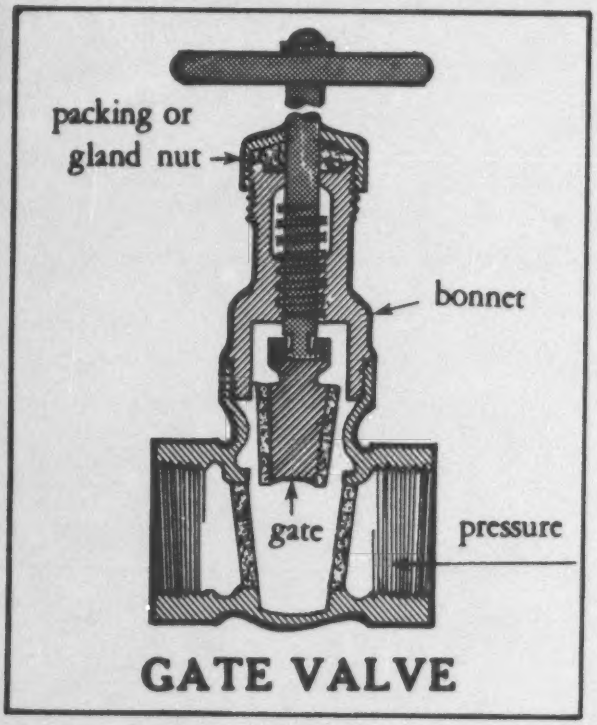
CAST IRON FITTINGS



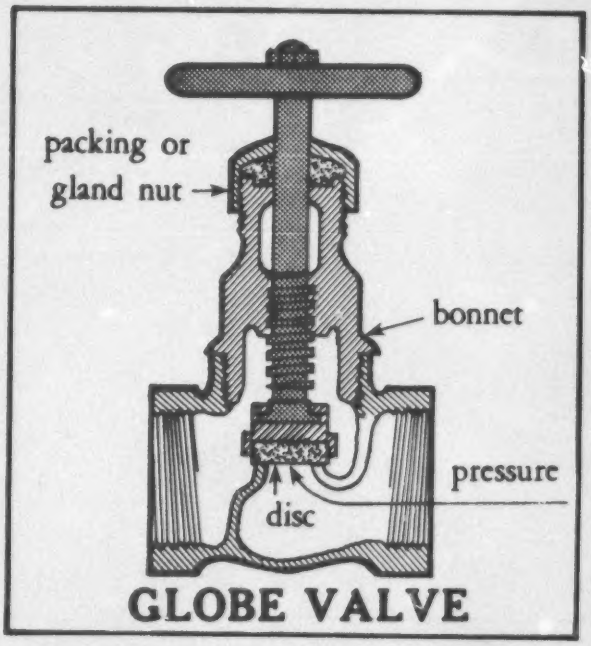
PLASTIC FITTINGS



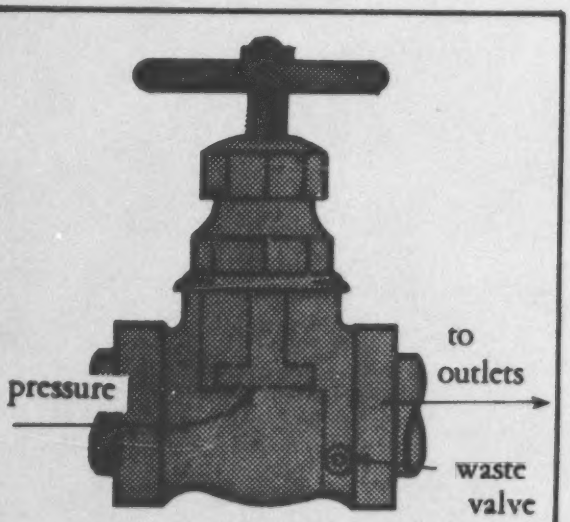
KINDS OF VALVES



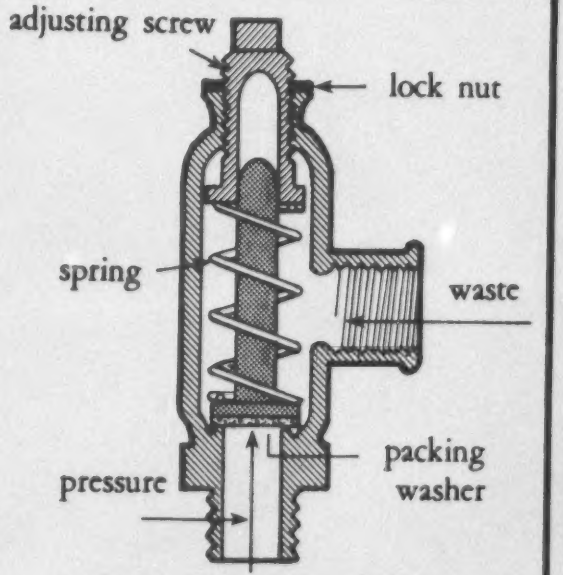
GATE VALVE



GLOBE VALVE



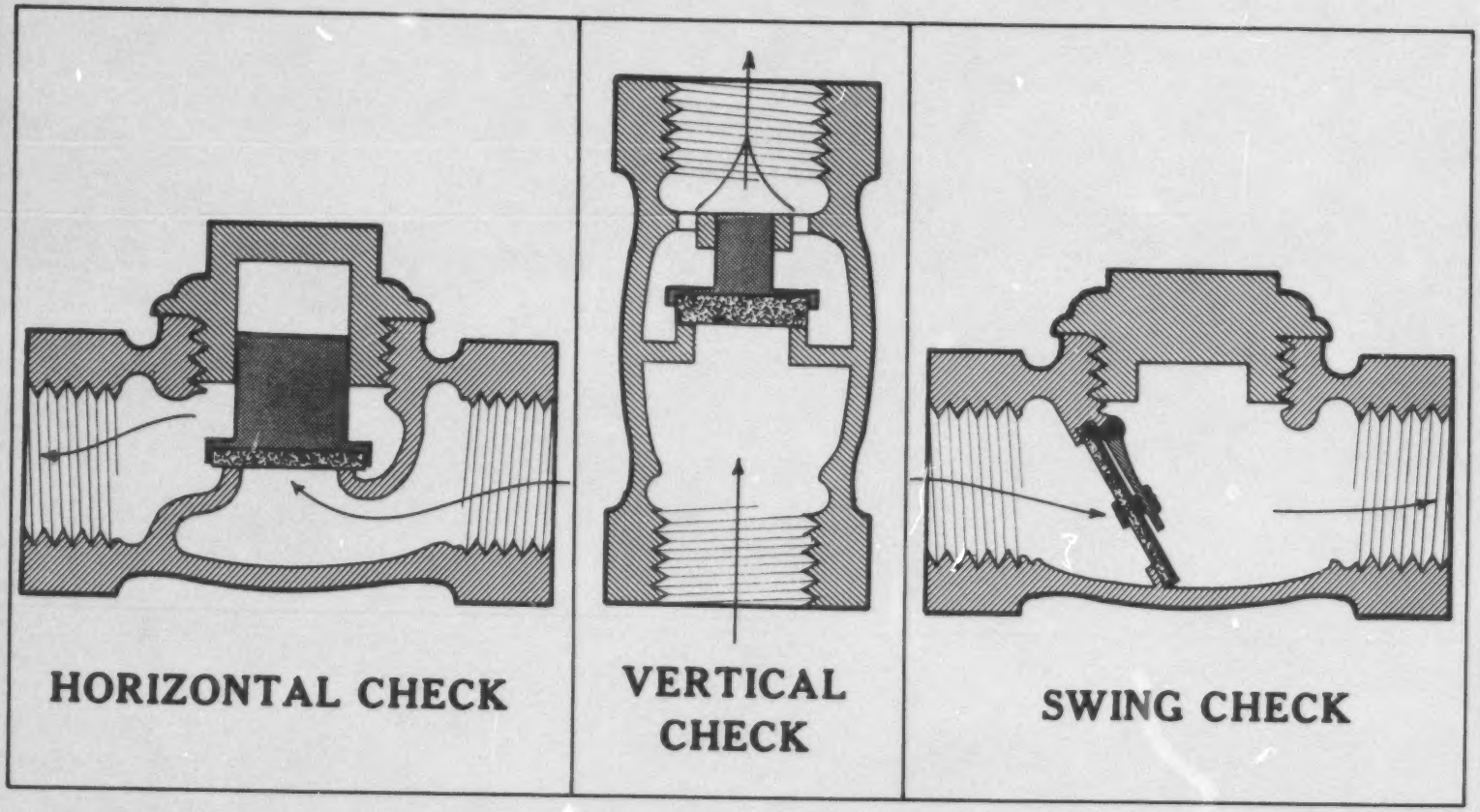
WASTE VALVE



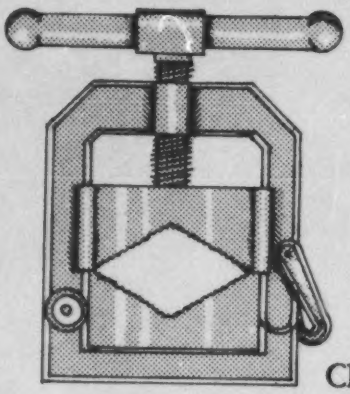
SAFETY VALVE

KINDS OF VALVES

CHECK VALVES

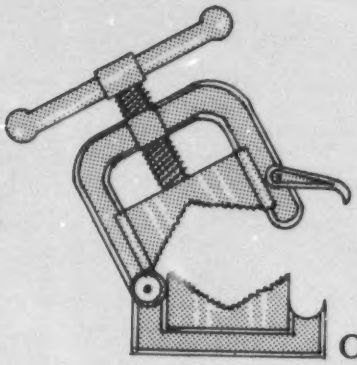


PLUMBING TOOLS

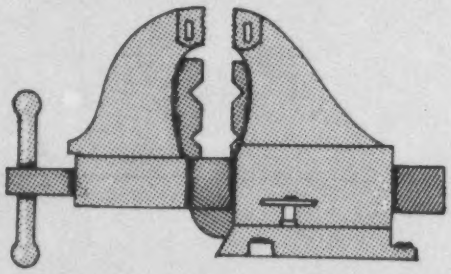


CLOSED

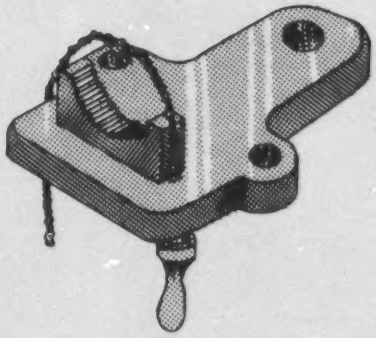
HINGED PIPE VISE



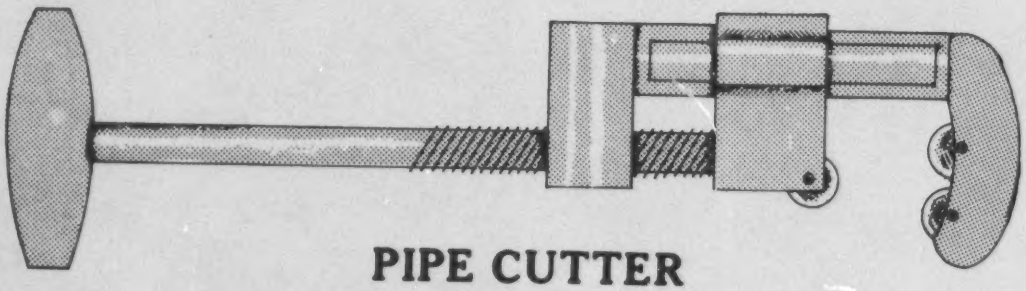
OPEN



COMBINATION PIPE VISE

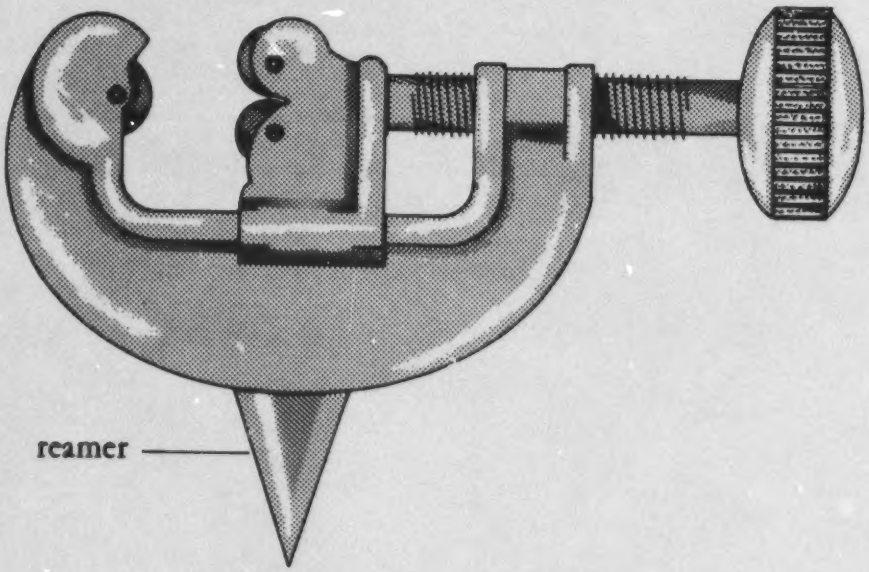


CHAIN PIPE VISE

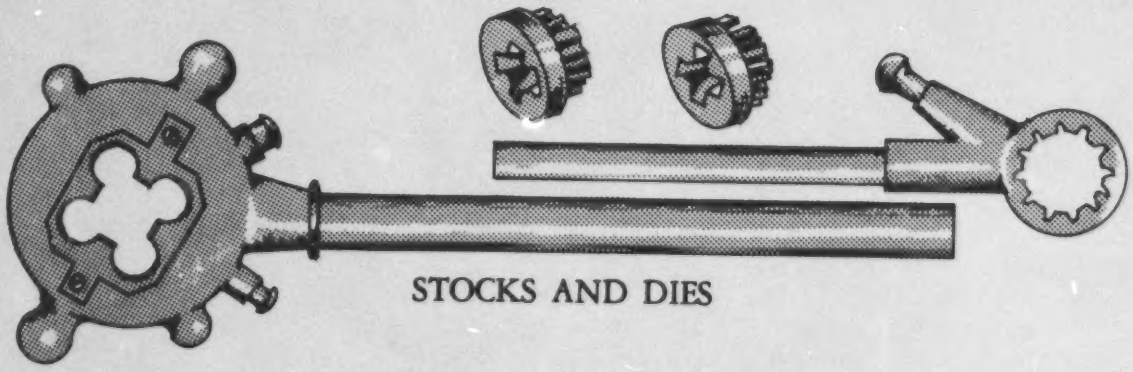


PIPE CUTTER

PLUMBING TOOLS



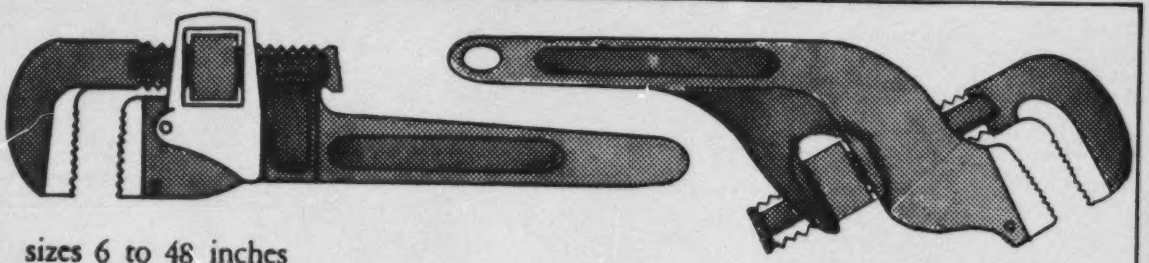
TUBE CUTTER



STOCKS AND DIES

PIPE THREADERS

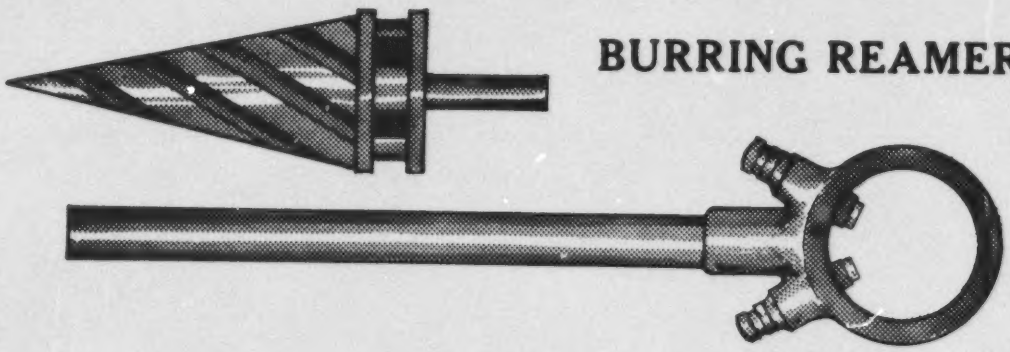
PLUMBING TOOLS



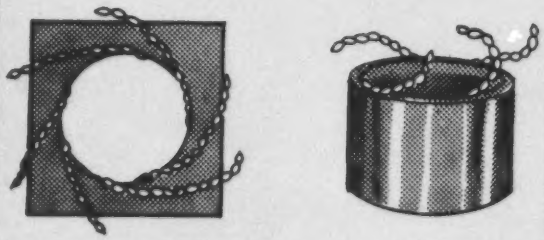
sizes 6 to 48 inches

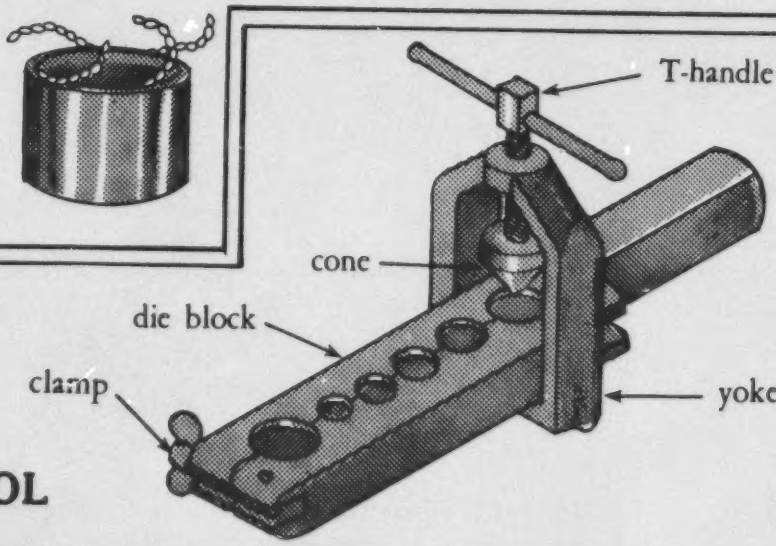
sizes 6 to 36 inches

PIPE WRENCHES



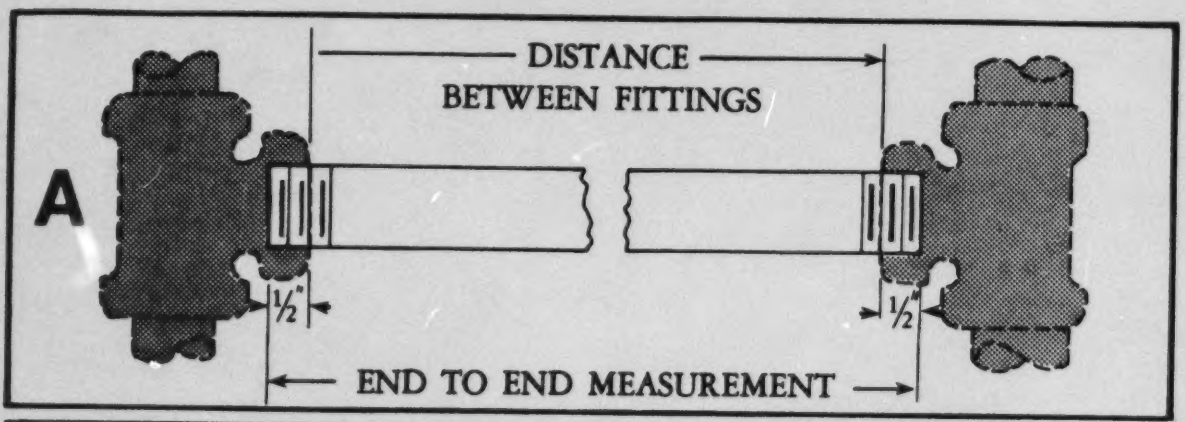
BURRING REAMER

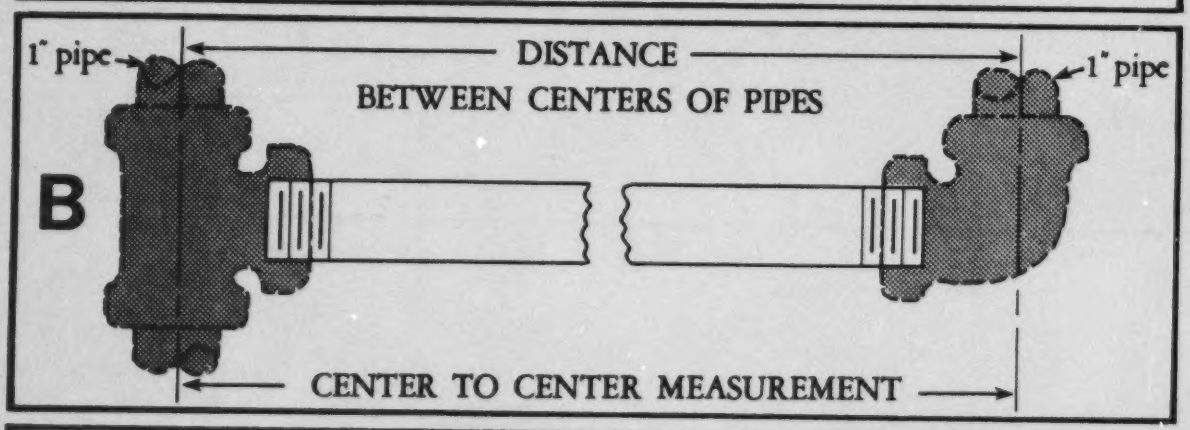


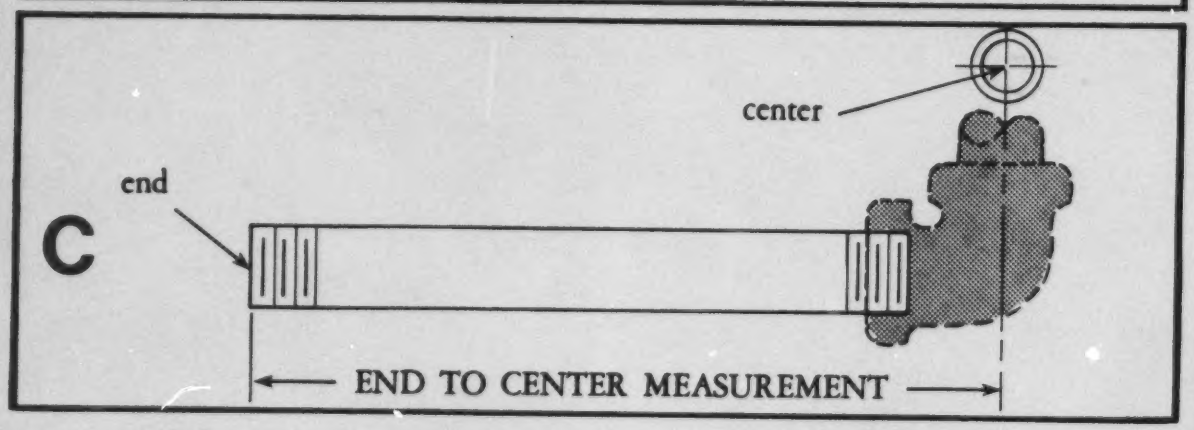


FLARING TOOL

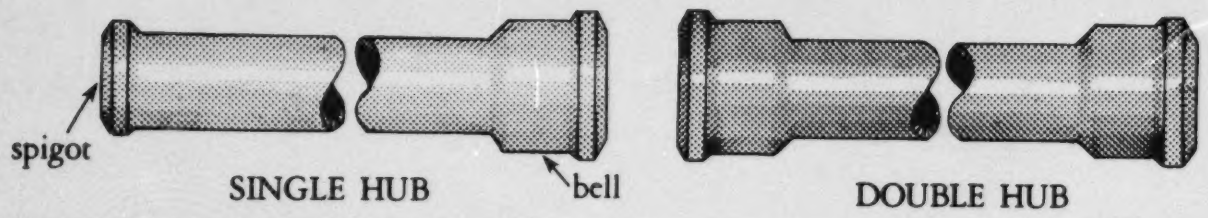
MEASURING PIPE





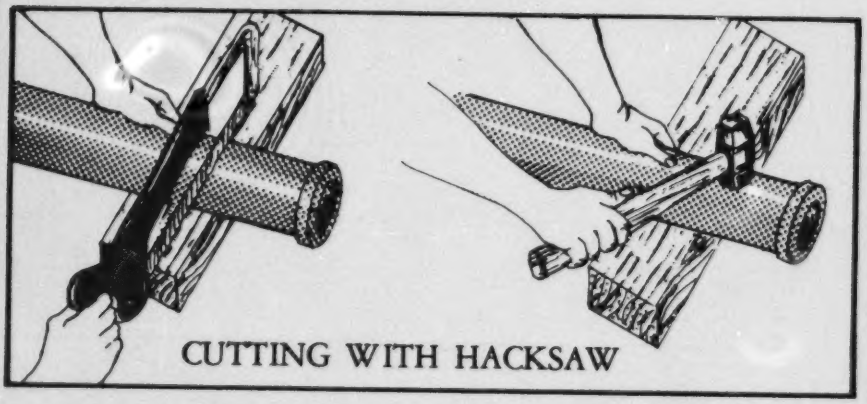


CUTTING AND ASSEMBLING CAST IRON SOIL PIPE



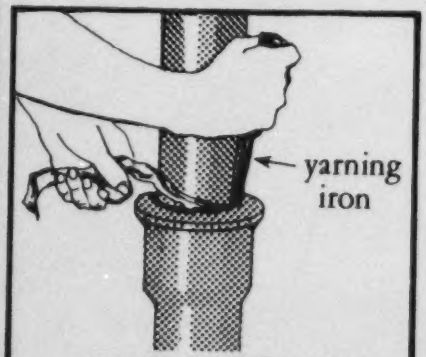
SINGLE HUB

DOUBLE HUB

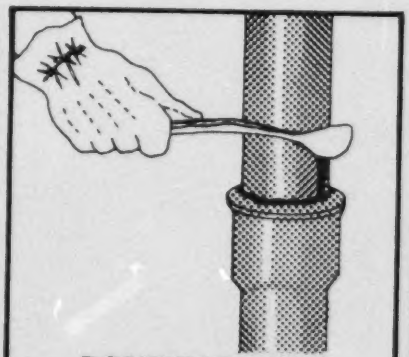


CUTTING WITH HACKSAW

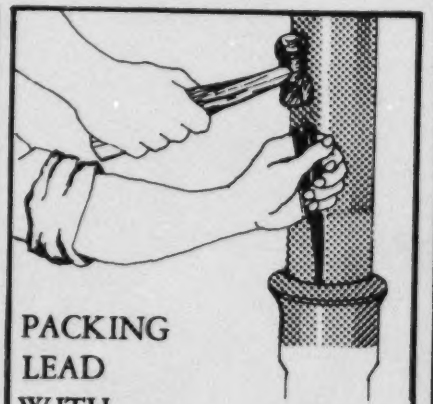
CUTTING WITH COLD CHISEL



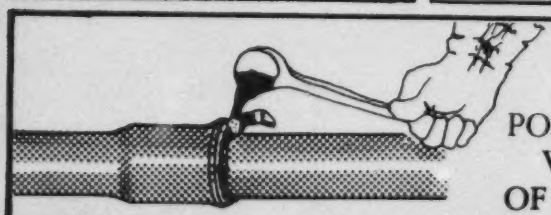
PACKING OAKUM



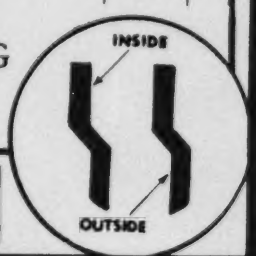
POURING LEAD



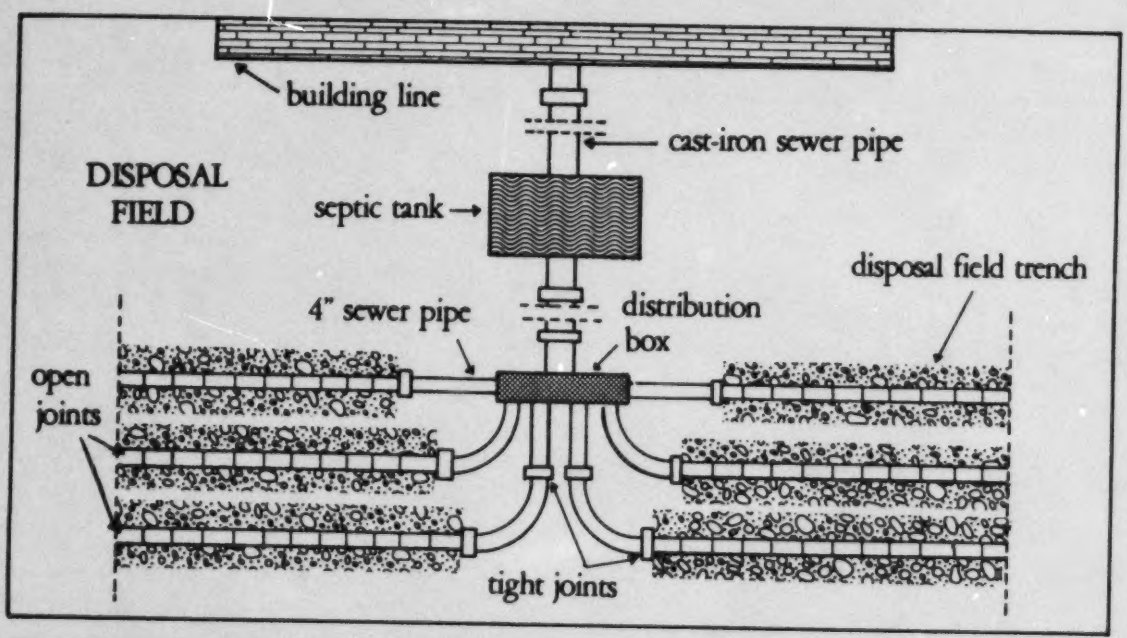
PACKING LEAD WITH CAULKING IRON

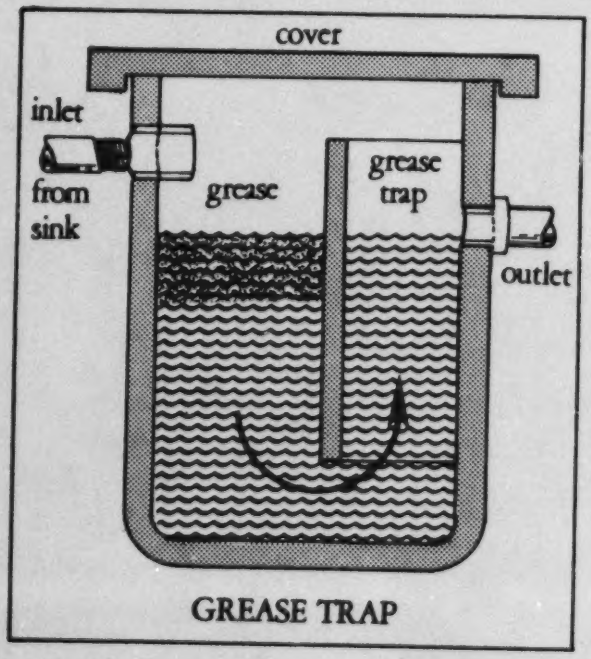


POURING LEAD WITH USE OF ASBESTOS JOINT-RUNNER

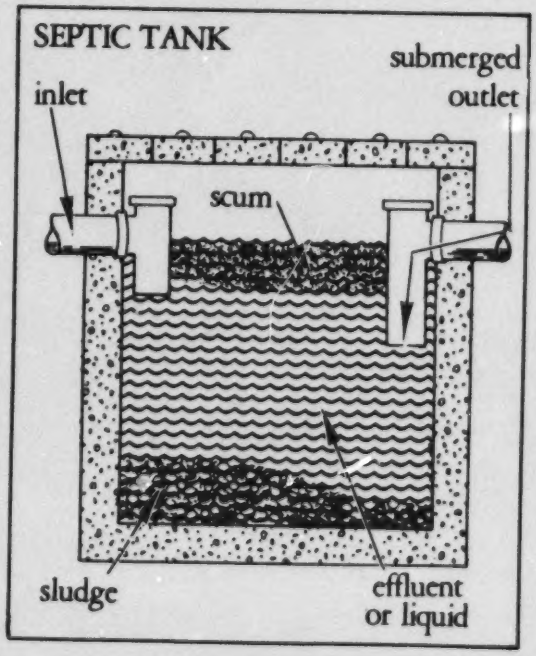


SEWAGE DISPOSAL





GREASE TRAP



CONSTRUCTION AND MAINTENANCE

Unit D: Farm Electricity

Topic 1: Electrical Safety and Terms

Suggested Procedure and Activities: In addition to the transparencies developed for this lesson, the use of the demonstration boards illustrated in the Texas Education Agency publication, "Wiring and Safety", should be helpful to the teacher in explaining the fundamentals of electricity. Safety in using electricity and the danger of electrical shock should be stressed throughout the lesson.

1. Definition of Electricity

For all practical purposes, electricity can be defined as a type of energy that can be converted to light, heat, or power. (Examples - light bulb, toaster, and motor)

Electricity may also be defined as a movement of electrons which is caused by "electrical pressure" or voltage.

2. Distribution of Electricity

Transparency No. 1

The generators at the power plant generate the electricity, developing 12,500 to 22,000 volts.

A step-up substation, through the use of transformers, increases the voltage to 69,000 volts, 138,000 volts, 345,000 volts, 500,000 volts, and up to 750,000 volts in some cases. This step-up in voltage is necessary for efficient transmission over long distances.

Transformers are used at the step-down substation to reduce the voltage to about 7,200 - 14,000 volts for distribution to rural and city areas.

Transparency No. 2

Transformers at the farm or home reduce the voltage to 120 volts or 240 volts to the meter of the customer.

3. Common Electrical Terms

Transparency No. 3

Electricity

Review the definition as stated earlier. (Energy converted to light, heat, or power.)

Ampere - (Amp.)

A unit of measure of the rate of flow of electricity. (This may be compared with the rate of flow of water in gallons per minute.) It should also be noted that the danger from electrical shock is from amperes flowing through the body.

Volt - (v)

A unit of measure of electrical pressure. Common service voltages are 120 volts or 240 volts. (Voltage may be compared with water pressure in pounds per square inch in a water system.)

Watts - (w)

A measure of electrical power. Electricity is measured in watts and is the work done by volts (pressure) pushing amperes (amps) through a wire. (Watts may be compared to the work done by water in washing a car.)

Kilowatt - (kw)

1000 watts. This unit of measure is used to obtain measurements that are more practical to use in computing electrical energy used. It is obtained by dividing the number of watts by 1,000.

Kilowatthour - (kwh)

Measurement of electricity in terms of power in kilowatts and time in hours. (1,000 watts used one hour.)

Alternating Current - (A.C.)

Current alternates or changes direction several times per second. Voltage can be easily increased or reduced by the use of transformers.

60 cycle

Current alternates or changes direction 120 times per second.

Direct Current - (D.C.)

Current flows in one direction.

Transformer

A device used to increase or reduce voltage.

Single Phase

The most common electric service to farms and homes. Requires one transformer between distribution line and meter.

Three Phase

Electric service that usually requires two or three transformers between distribution line and meter. Not generally available to customers with normal electrical needs. Several large (10 hp and larger) motors would justify three phase service.

Short Circuit

A direct connection (before current flows through an appliance) between two "hot" wires, between a "hot" and "neutral", or between a "hot" wire and ground.

Voltage Drop

The reduction of voltage between the power supply and the load. Factors affecting voltage drop are size of wire, length of wire, and the number of amperes flowing.

A voltage drop results in loss of heat, loss of light, or loss in power output of a motor. It may endanger a motor if the motor is not properly protected with time-delay fuse or circuit breaker.

The selection of the proper size wire to provide sufficient voltage to appliances is an important consideration in planning electrical circuit installations. Tables Nos. 2, 3, 4, 5, 6, 7, 8, and 9 in Reference No. 1 may be used by the teacher to demonstrate the selection of wire sizes on the basis of permissible voltage drop.

4. Computing Electrical Power Used By Heating and Lighting Appliances

Transparency No. 3

The basic formula for determining the number of watts used is:

Watts = Volts x Amperes

For determining the number of amperes flowing in a circuit:

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$$

For determining the number of volts:

$$\text{Volts} = \frac{\text{Watts}}{\text{Amperes}}$$

5. Computing Electrical Power Used By Motors

Transparency No. 4

Electric motors are rated or sized in horsepower (hp). This measurement of mechanical power is equal to 746 watts of electrical power.

Electric motors are not 100% efficient, so more than 746 watts are required for a motor to develop one horsepower.

Rules of Thumb for Figuring the Operating Cost of Motors:

1 hp and larger - Estimate 1000 watts per horsepower

Less than 1 hp - Estimate 1200 watts per horsepower

6. Cost of Operating Electrical Equipment

Transparency No. 5

Watts x Hours of Operation = Watthours

$$\frac{\text{watthours}}{1000} = \text{Kilowatthours (kwh)}$$

Coffee Pot = 550 watts × 8 hours = 4400 watthours

$$\frac{4400 \text{ watthours}}{1,000} = 4.4 \text{ kwh}$$

Electricity @ 4¢ per kwh

4.4 kwh x 4¢ = 17.6 or 18¢

Cost Examples:

Operate a 2 hp motor (2000 watts) for 2 hours

2000 w x 2 hrs = 4,000 watthours

$\frac{4000 \text{ watthours}}{1000}$ = 4 kwh @ 4¢ = 16¢

Operate a 1/3 hp motor (400 watts) for 8 hours

400 w x 8 hrs = 3200 watthours

$\frac{3200 \text{ watthours}}{1000}$ = 3.2 kwh @ 4¢ = 12.8¢

7. Definition of an Electrical Circuit

Transparency No. 6

An electrical circuit is a completed path through which electricity flows. Insulated conductors (wires) conduct the electricity.

The "hot" wire from the power source is a current-carrying conductor with electrical pressure (voltage) on it. The "hot" wire, usually black or red, conducts the current to the appliance.

The "neutral" wire conducts the current from the appliance to the source (ground). The "neutral" wire, usually white, has no electrical pressure (voltage) on it.

Most circuits include a switch to open or close the circuit.

Circuits should be protected from too many amperes by a protection device (fuse or circuit breaker).

8. Electrical Circuit Compared To Water System

Transparency No. 7

As indicated earlier, an electrical circuit may be compared to a water system for a clearer understanding of the circuit.

Water Pressure - Electrical Pressure (Volts)
Rate of Flow - Rate of flow (Amperes)
Work Done - Power (Watts)

If the switches are closed, current will flow through the fuse, hot wire, appliance, and back to source (ground) on the neutral wire.

If the neutral wire is disconnected from the neutral bar in the fuse box and connected to the earth, current will flow. A person standing on the ground may act as a conductor if a hot wire or broken neutral wire is touched, resulting in electrical shock.

9. Differences In 120 Volt and 240 Volt Circuits

Transparency No. 8

The 120 volt circuit has one hot and one neutral wire with the switch and fuse in the hot line. The neutral wire from the appliance is connected to the neutral bar in the fuse box. For safety, the neutral wire should always be solid and not broken or interrupted with a switch or fuse.

The voltage is measured with a voltmeter with one lead on the hot terminal and the other lead on the neutral bar. The number of amperes flowing may be measured with a clamp-on ammeter by encircling the hot or neutral wire with the jaws of the ammeter.

The 240 volt circuit has two hot wires and one safety-ground wire with the switches and fuses in the hot lines. The safety-ground wire, connected to the metal frame of the welder and to the neutral bar, does not carry current unless the welder develops a "short". If a "short" occurs, one of the fuses will "blow" to open the circuit.

The voltage is measured with one lead of the voltmeter on one hot terminal and the other lead of the voltmeter on the other hot terminal. Voltage between either hot terminal and the neutral bar will be one-half of the voltage between the two hot wires. The number of amperes flowing can be measured by clamping a clamp-on ammeter around either hot wire.

10. Safety Grounding Electrical Equipment

Transparency No. 9

The metal frame of an ungrounded electrical tool or appliance may come in contact with a damaged or bare wire inside the frame. The metal case will then be energized or charged with electricity. If the case is touched by a person who is grounded, the current will flow through the person to the ground. The shock could be fatal.

To prevent this possibility of shock, a safety-ground wire, properly installed, will carry the current from the metal case to the ground, causing a direct short which, in turn, will cause the fuse to "blow" or the circuit breaker to open.

The diagram of the electric drill illustrates the practice of safety grounding. Any electrical appliance may be safety grounded to protect against electrical shock by connecting a ground wire from the metal frame of the appliance to the neutral bar in the panel box. The safety-ground wire may be bare, but if insulated, the insulation of a safety-ground wire is usually green in color.

A current-carrying neutral wire should never be used to connect a safety-ground wire to ground. A safety-ground wire should never be used as a current-carrying neutral wire.

Each outlet circuit should be installed with a safety-ground wire, and grounded receptacles should be provided. This will allow any safety-grounded appliance to be plugged into the outlet without an adapter.

When an adapter must be used, the green pigtail wire should be grounded to furnish protection from electrical shock to the operator of the appliance.

Using a test lamp (light bulb in pigtail socket with two leads), show how a circuit is completed between a "hot" wire and a "neutral" wire.

Using the test lamp, demonstrate how to check appliances for "shorts". With appliance plugged into an outlet, touch the appliance frame with one lead of the test lamp while the other lead of the test lamp is grounded to a water or gas line. If test lamp does not burn, turn appliance plug over and check with test lamp again. If light burns, a short exists. (Hot wire is touching the frame of the appliance.) Unplug appliance and explain how to repair.

11. Circuit Protection

Each electrical circuit should be protected from an over-load in amperes. Too many amperes flowing through an unprotected circuit will generate heat which may deteriorate or melt the insulation and/or cause a fire.

The number of amperes that any given conductor can carry safely depends upon the kind and size of wire, the type of insulation, and the type of installation.

Allowable current-carrying capacities of various conductors may be found in Table 1 of Reference No. 1.

Types of Circuit Protection

Transparencies Nos. 10, 11, 12, and 13

a. Common Fuses
   (1) Plug
   (2) Cartridge
   (3) Blade
b. Fusetrons
   (1) Plug
   (2) Cartridge
   (3) Blade

Time Delay Action

c. Fustats - (Two Parts)
d. Circuit Breakers

Fuses, fusetrons, fustats, or circuit breakers must be of the proper size to protect each individual circuit. (Examples - A No. 14 gauge copper wire should be protected with a 15 ampere protection device. A 20 ampere fuse may be used to protect a No. 12 gauge copper conductor.)

Electric motors cannot be protected by a common fuse. To properly protect motors, the motor circuit must have a time-delay fusetron, fustat, or circuit breaker in the circuit.

The time-delay action allows the higher amperage required for the motor to start to flow for a short time without "blowing" the fuse or opening the circuit breaker. If the high-amperage flow continues after the motor gains its operating speed, the heat will cause the fuse to "blow" or the circuit breaker to open.

This time-delay principle is essential to fuse the circuit closely enough to protect the motor. (The time-delay fuse or circuit breaker should not be more than 25% larger than the amperage rating of the motor. A common fuse of the same size will "blow" each time the motor attempts to start.)

A circuit is not protected when a penny is placed behind a common fuse. Fustats are designed so that a penny cannot be placed behind the fustat. (The opening in the fustat base is too small for the penny.) The threads of fustats are designed to prevent over-size fusing.

Excessive ampere flow in a circuit breaker causes the heater strip to heat the bi-metal strip which trips the breaker, opening the circuit. The circuit breaker can be reset after it is allowed to cool.

12. No Fault Grounding

Fuses and circuit breakers are safety devices which limit current (amperage) in a circuit. Their main function is to protect equipment and wiring from overload. Ground fault circuit interrupters (GFCI) are designed to protect humans, equipment, and/or electrical systems from injury or damage if electricity flows in an unintended path (a short).

A GFCI is a very sensitive device that functions by comparing the current flowing in the "hot" wire with that in the neutral wire. If these two currents are not equal, a fault exists, and current is "leaking" out of the circuit. If the difference in current between the two wires is 5/1000 of an ampere or greater, the GFCI will open the circuit, shutting off the power and eliminating any shock hazard.

The National Electrical Code requires GFCI's for all 120 V, single phase, 15 and 20 amp receptacles installed outdoors, in bathrooms, and in garages for residential buildings. A GFCI is required at construction sites and some other applications. After correcting the circuit fault (short), the GFCI may be reset for further use.

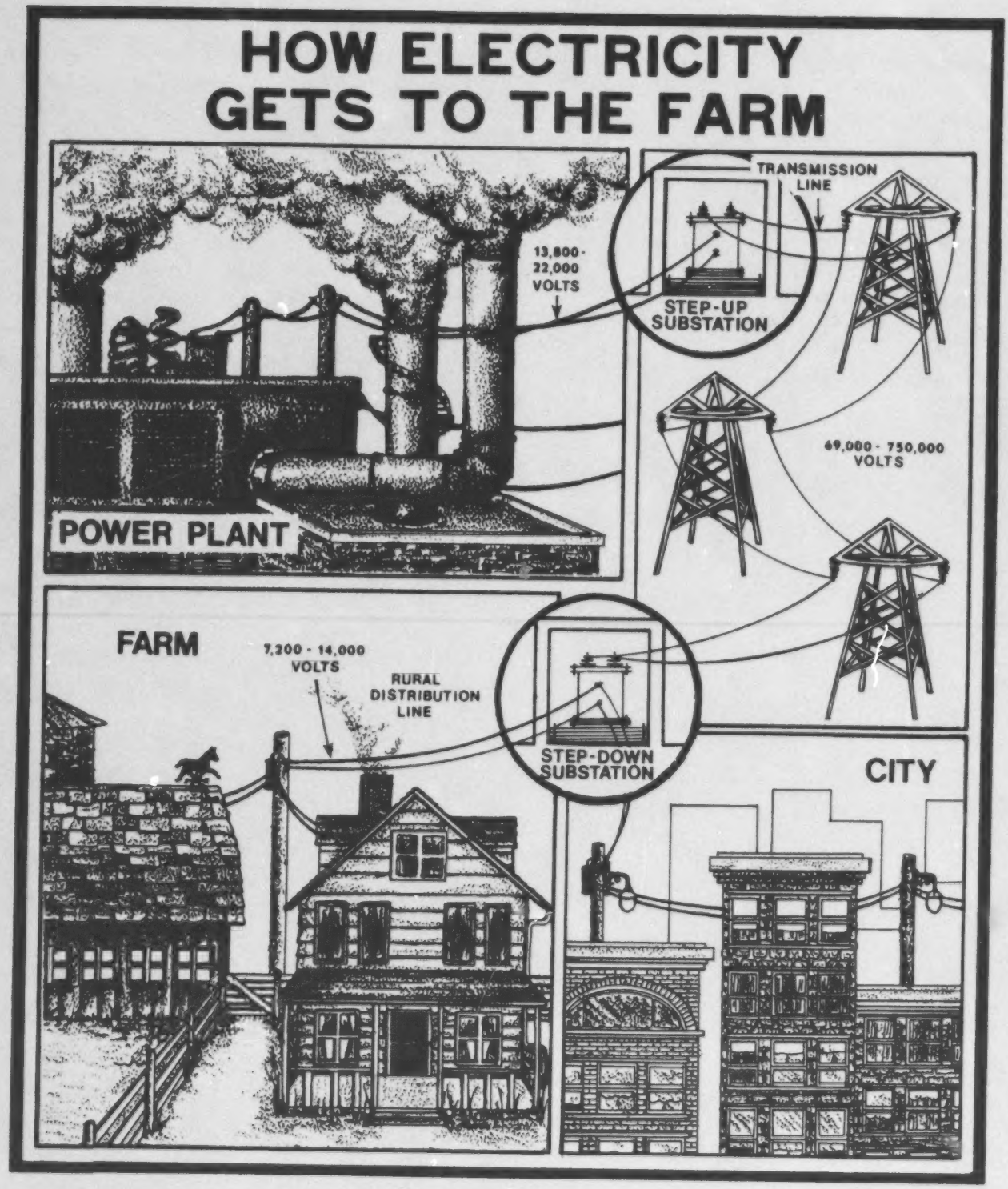
A variety of GFCI equipment is made for 120 and 240 volt circuits. GFCI's can be installed in place of a circuit breaker or convenience outlet, and may be portable for use with extension cords.

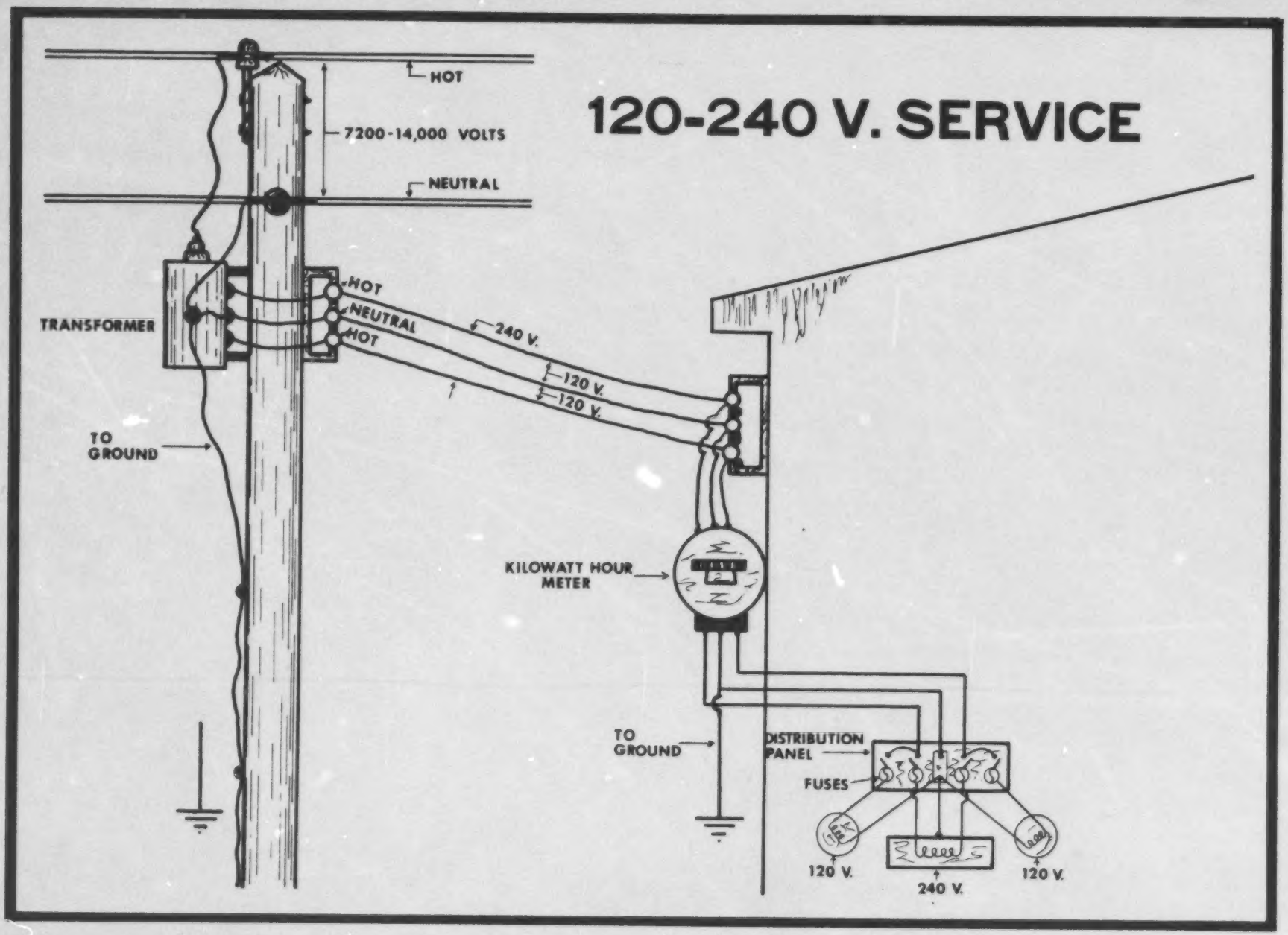
References:

1. Texas Education Agency, "Farm Electrification Lesson Plans - Wiring and Safety", Vocational Instructional Services, Texas A&M University, College Station, Texas.

2. "Agricultural Wiring Handbook", Food and Energy Council, Inc., 909 University Avenue, Columbia, MO 62501, 1978.

3. Henderson, G. E., "Understanding Electricity and Electrical Terms", American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia 30602, 1974.


HOW ELECTRICITY GETS TO THE FARM
TRANSMISSION LINE
13,800 - 22,000 VOLTS
STEP-UP SUBSTATION
69,000 - 750,000 VOLTS
POWER PLANT
FARM
7,200 - 14,000 VOLTS
RURAL DISTRIBUTION LINE
STEP-DOWN SUBSTATION
CITY


120-240 V. SERVICE
HOT
7200-14,000 VOLTS
NEUTRAL
TRANSFORMER
HOT
NEUTRAL
HOT
240 V.
120 V.
120 V.
TO GROUND
KILOWATT HOUR METER
TO GROUND
DISTRIBUTION PANEL
FUSES
120 V.
240 V.
120 V.

COMMON ELECTRICAL TERMS

electricity - light, heat, power

ampere (amp.) - rate of flow
example: (water - gal./min.)

volt (v) - pressure
example: (lbs./sq. in.)

watts (w) - power
example: (hp)

kilowatts (kw) - 1000 watts

horsepower (hp) - 746 watts = 1 hp

kilowatt-hour (kwh) - 1000 watts used in 1 hour

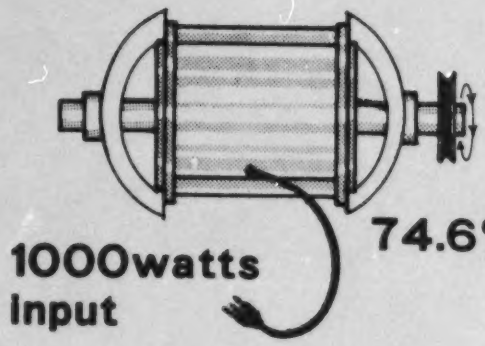
volts x amps = watts

$$\text{amps} = \frac{\text{watts}}{\text{volts}}$$

$$\frac{\text{60 watt lamp}}{\text{240 volts}} = \text{¼ amps.}$$

$$\frac{\text{60 watt lamp}}{\text{120 volts}} = \text{½ amps.}$$

EFFICIENCY OF MOTORS



1000watts
input

74.6% eff.

1 hp or 746 watts
output

1 hp motor

$\text{eff.} = \frac{\text{output} \times 100}{\text{input}}$	$\text{eff.} = \frac{746 \times 100}{1000} = 74.6\%$

rule of thumb:

1 hp motor uses 1000 watts

COST OF OPERATING ELECTRIC EQUIPMENT

watts x hours of operation = watt hours

$$\text{kilowatt-hours (kwh)} = \frac{\text{watts x hours}}{1000}$$

one 550 watt coffee pot = 550 watts
x 8 hours
4400 watt hours

$$\frac{\text{4400 watt hours}}{1000} = \text{4.4 kwh}$$

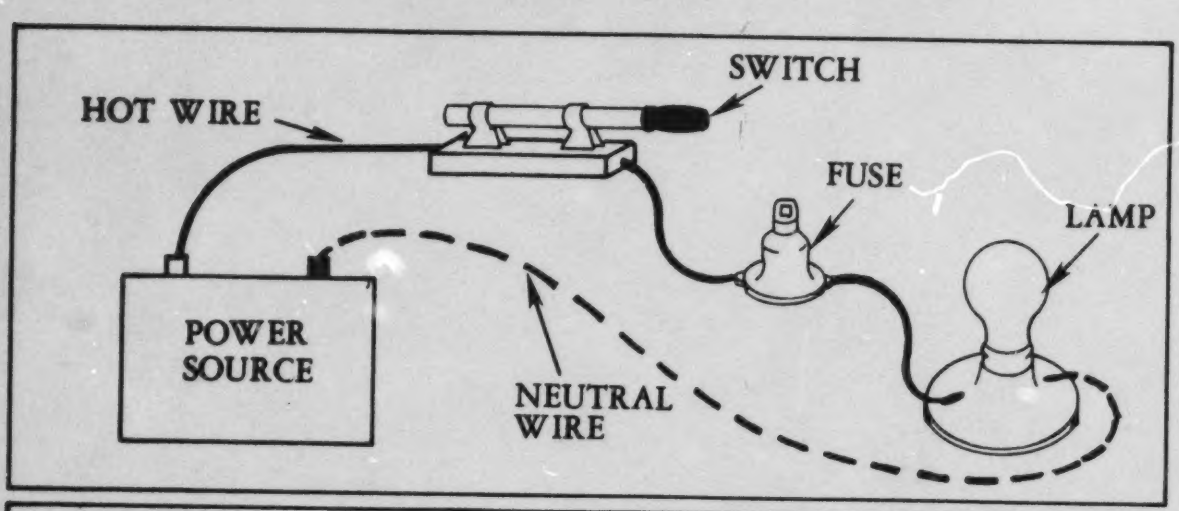
electricity @ 4¢/kwh

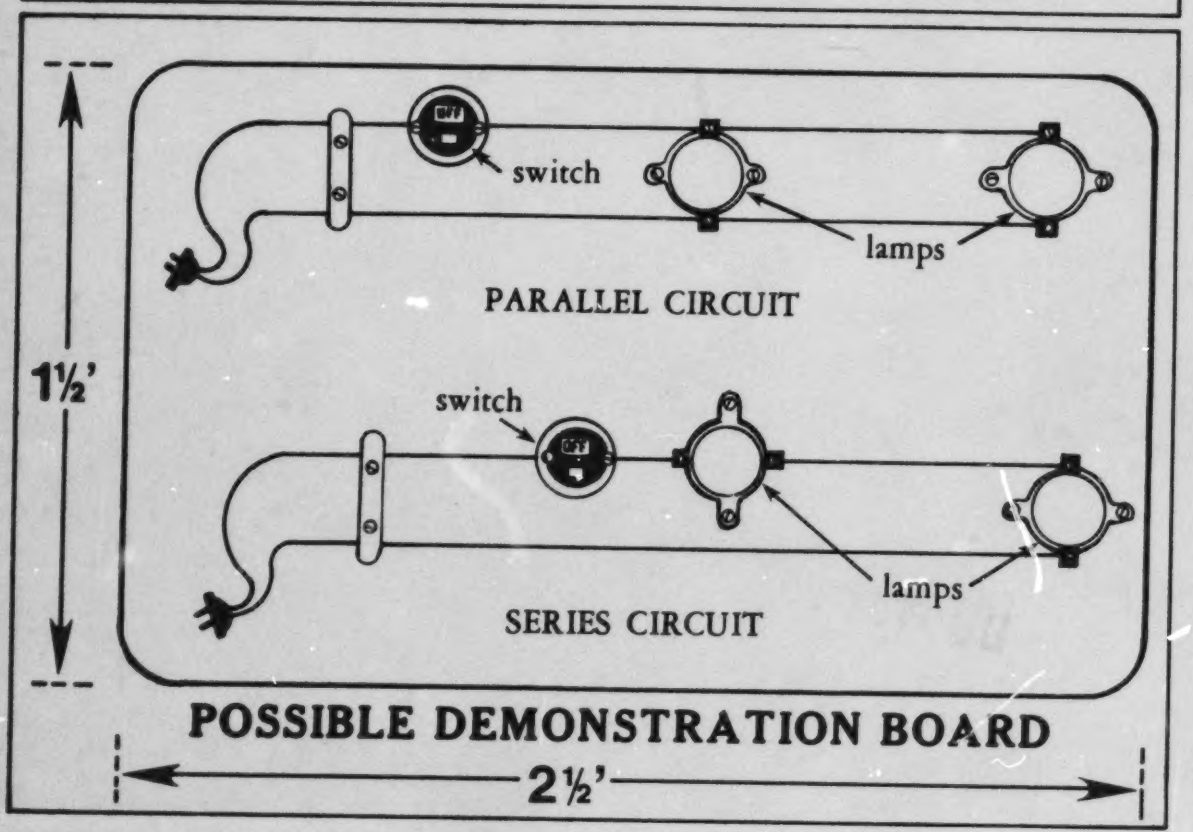
4.4 kwh x 4¢/kwh = 17.6¢

operation of a 2 hp motor (2000 watts)
for 2 hours = 4000 watt hours

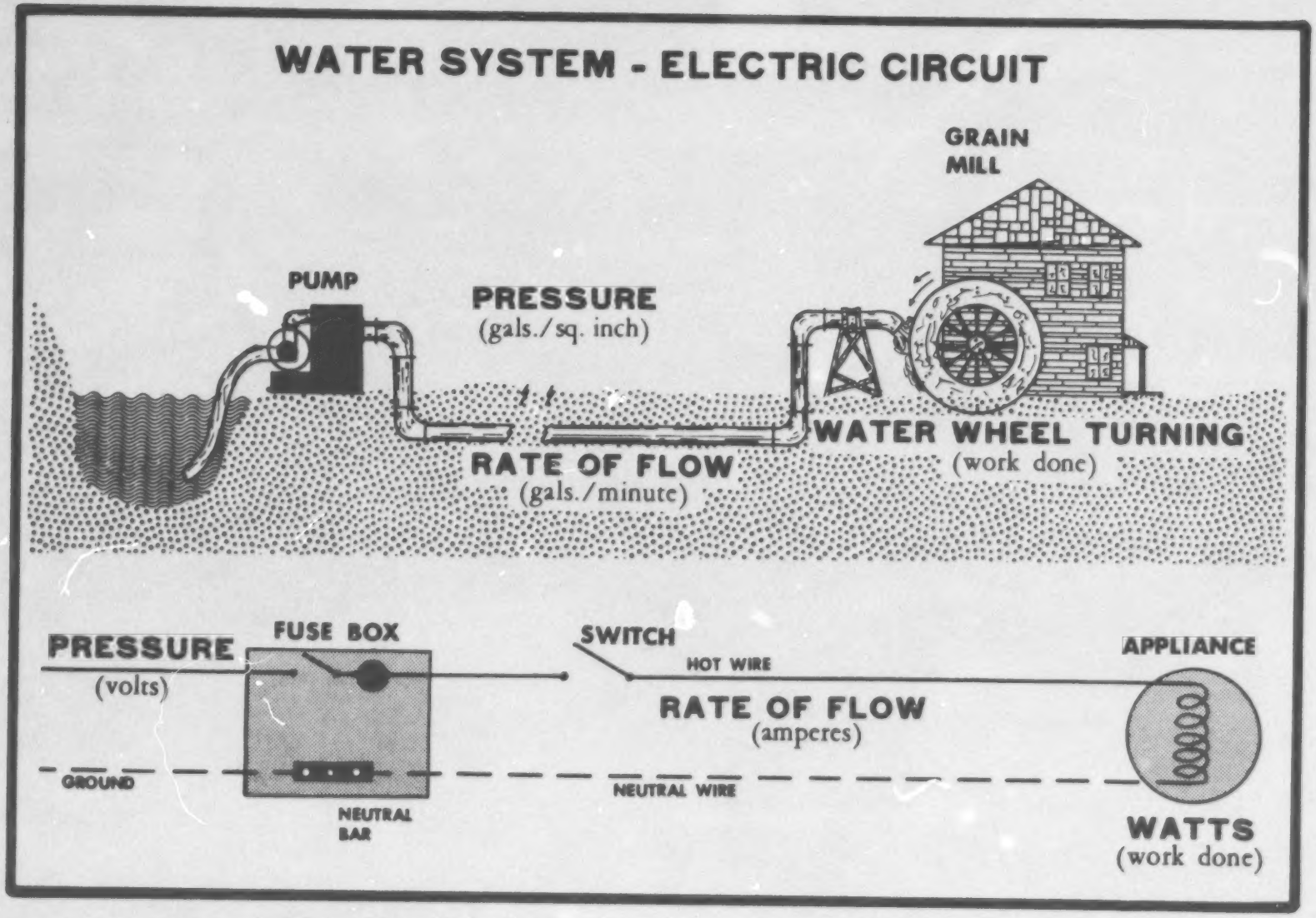
4.0 kwh x 4¢ = 16¢

SIMPLE CIRCUITS

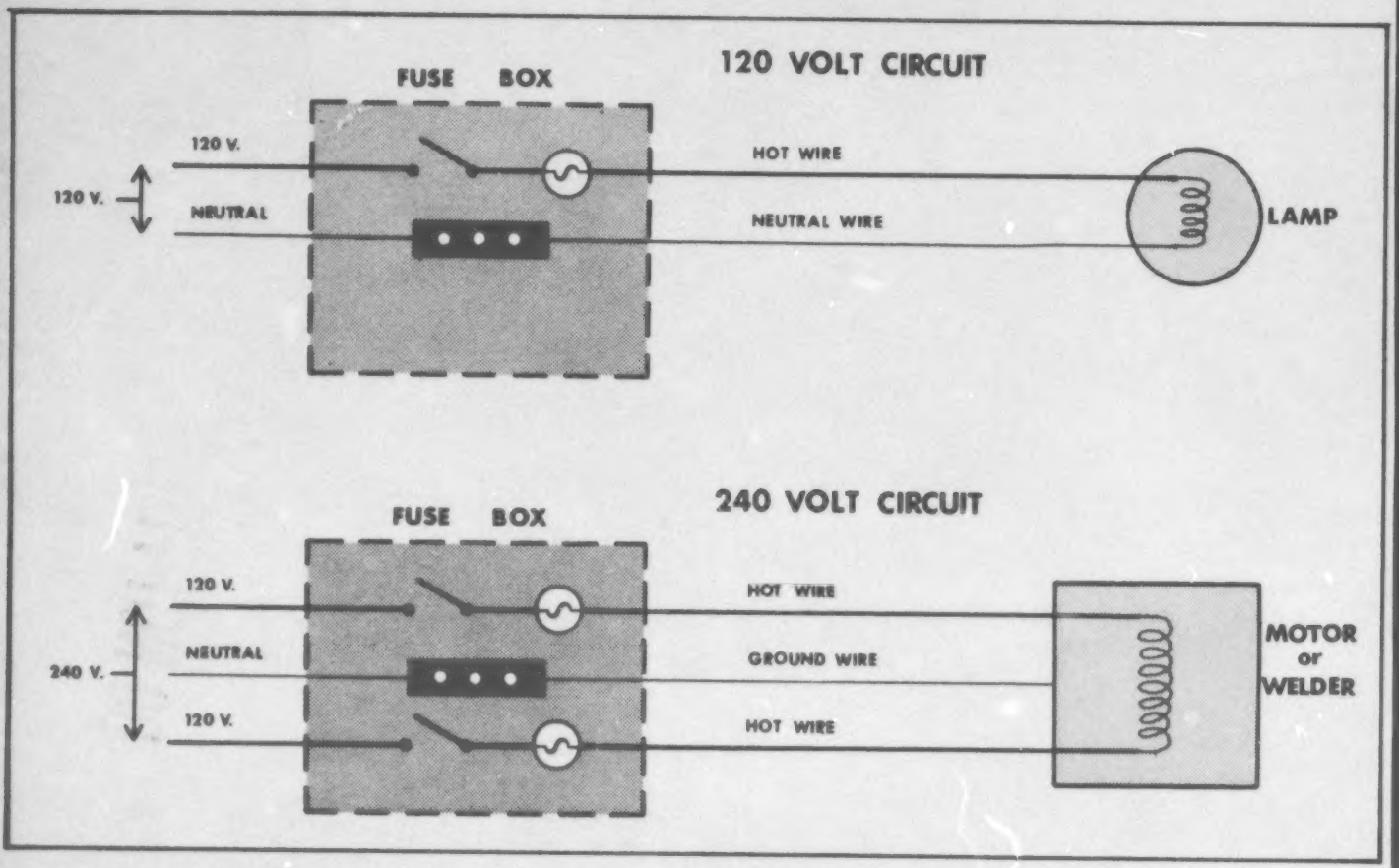




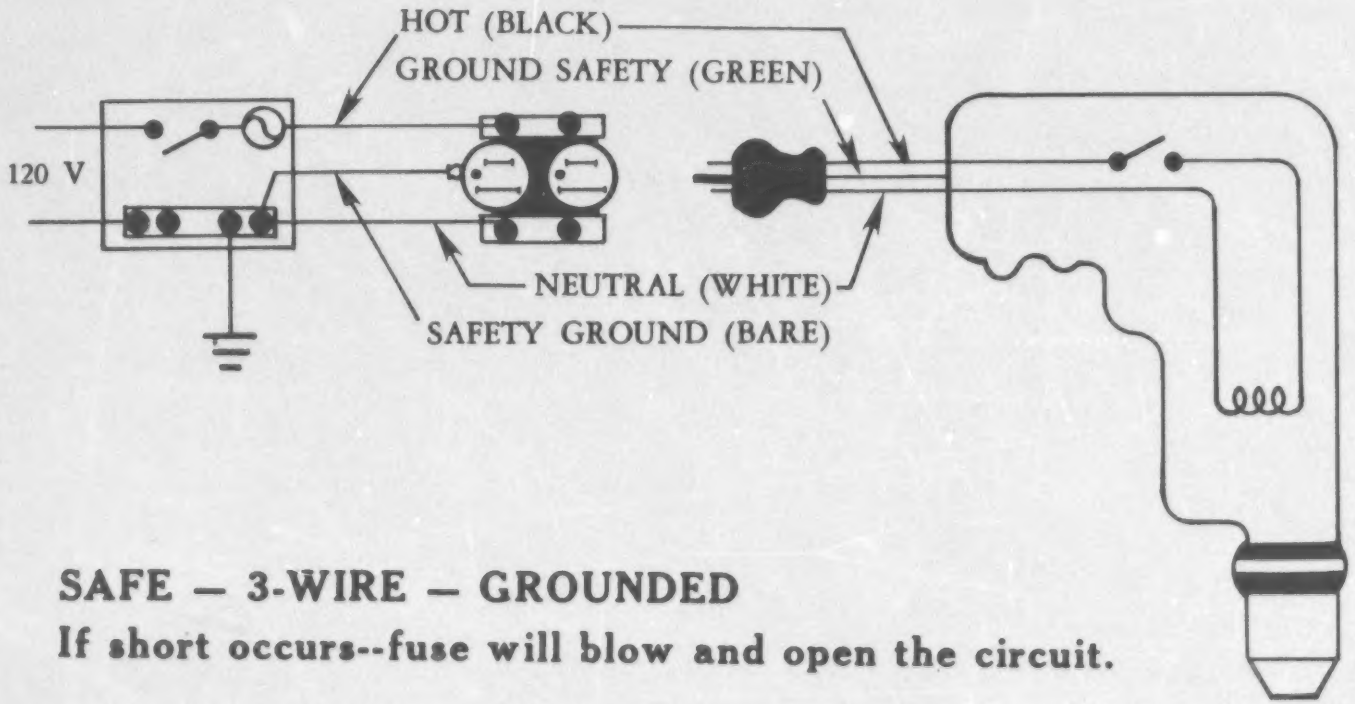
POSSIBLE DEMONSTRATION BOARD


WATER SYSTEM - ELECTRIC CIRCUIT
GRAIN MILL
PUMP
PRESSURE
(gals./sq. inch)
WATER WHEEL TURNING
(work done)
RATE OF FLOW
(gals./minute)
PRESSURE
(volts)
FUSE BOX
SWITCH
HOT WIRE
APPLIANCE
RATE OF FLOW
(amperes)
GROUND
NEUTRAL WIRE
NEUTRAL BAR
WATTS
(work done)

120-240 VOLT CIRCUITS



SAFETY-GROUNDING AN ELECTRIC DRILL



SAFE – 3-WIRE – GROUNDED

If short occurs--fuse will blow and open the circuit.

CIRCUIT PROTECTION

① COMMON FUSES

PLUG

CARTRIDGE

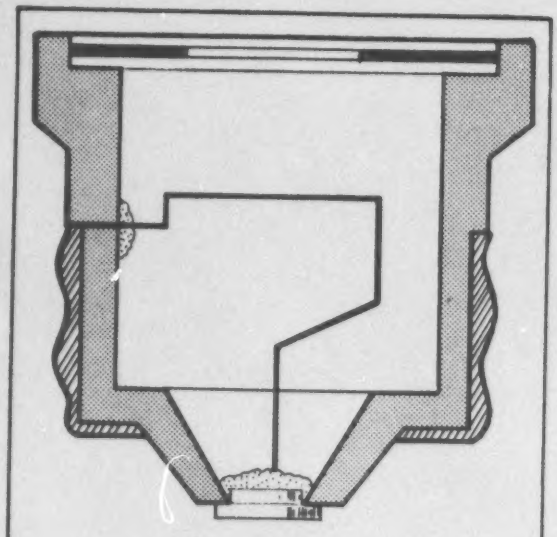
② FUSETRONS (time delay action)

PLUG CARTRIDGE

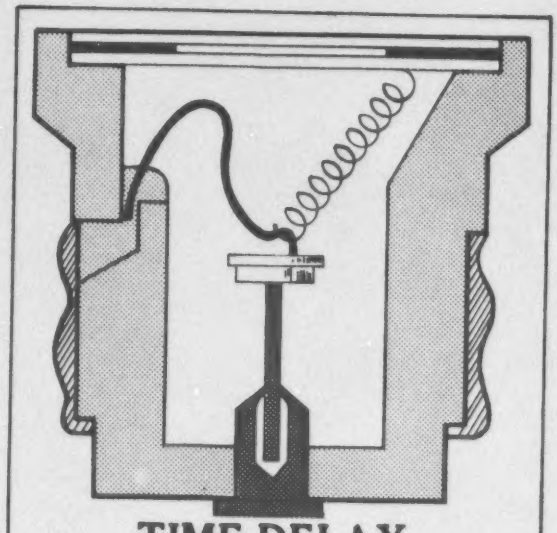
③ FUSTATS (time delay action)

④ CIRCUIT BREAKERS
(time delay action)

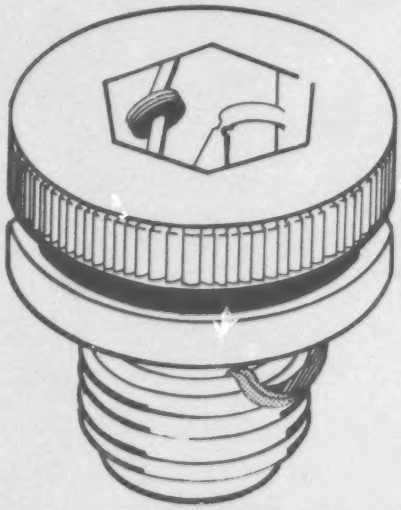
TYPES OF FUSES



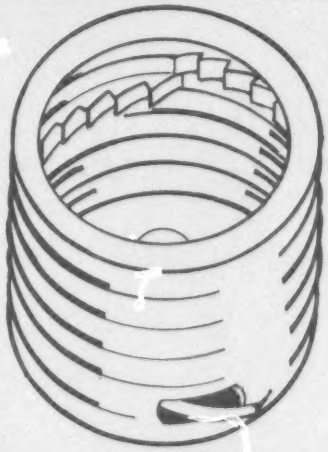
PLUG FUSE



TIME DELAY FUSE

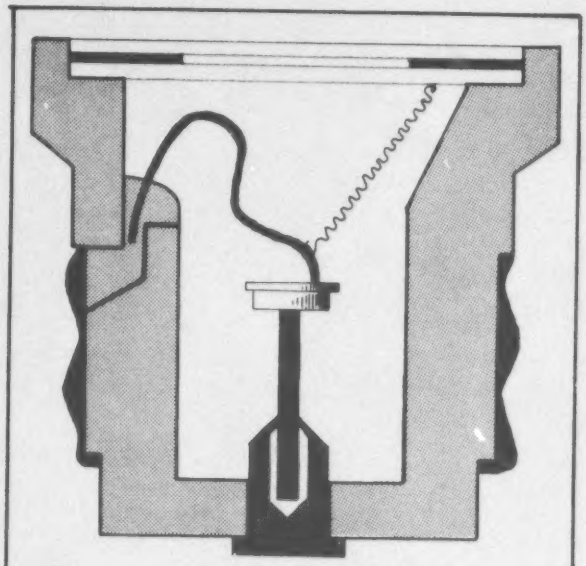


FUSTAT

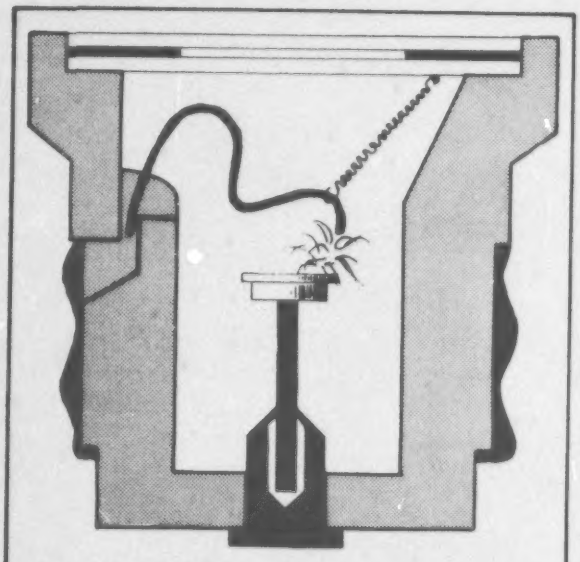


ADAPTER

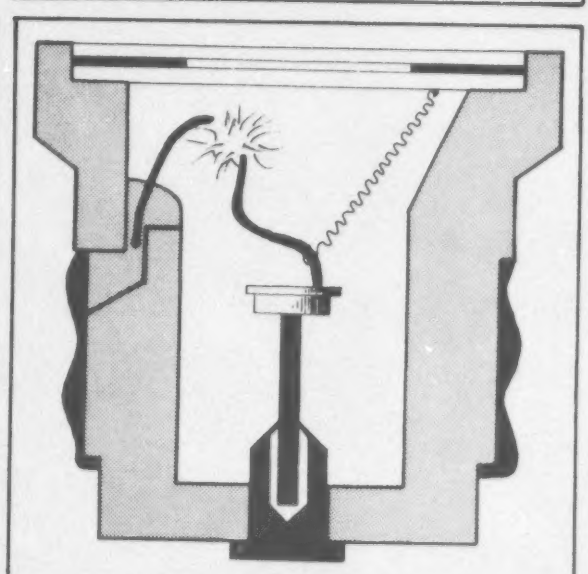
OPERATING PRINCIPLE OF A DELAYED ACTION FUSE



NORMAL

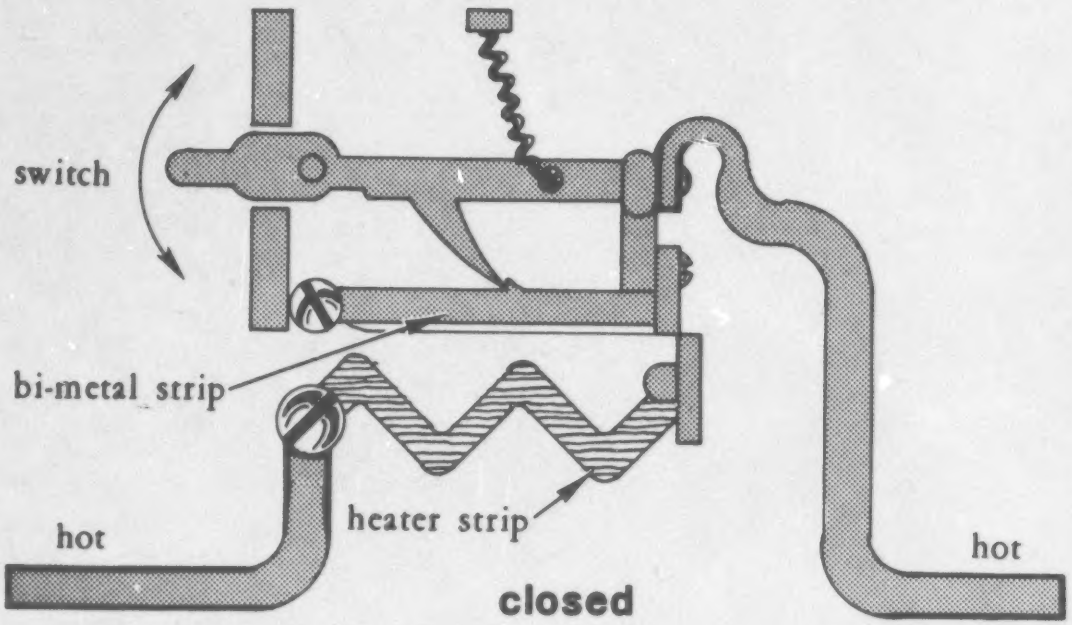


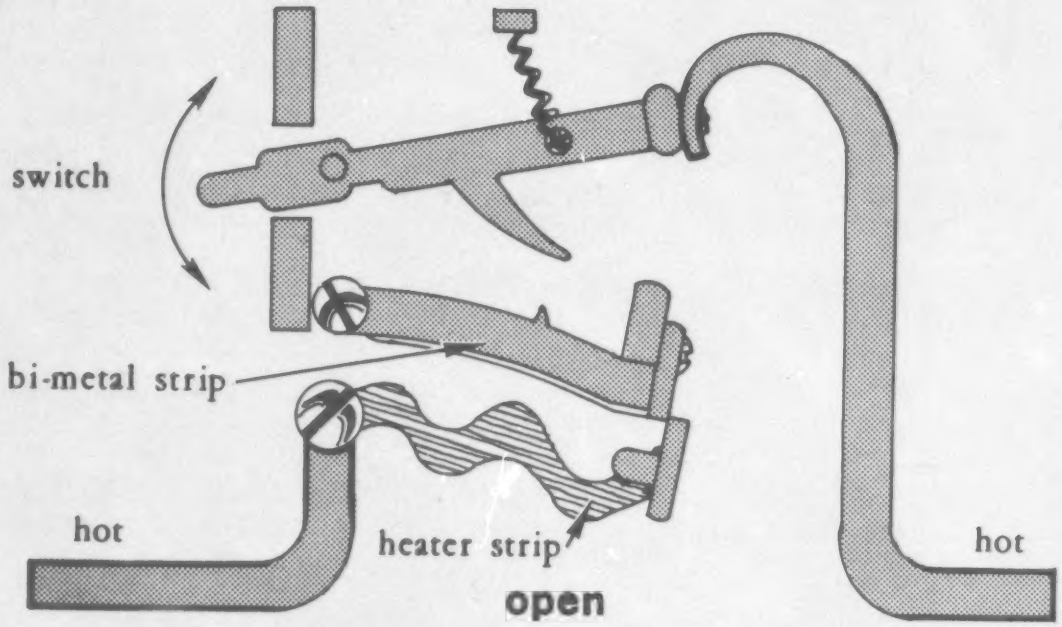
CONTINUED OVERLOAD



SHORT CIRCUIT

CIRCUIT BREAKER





CONSTRUCTION AND MAINTENANCE

Unit D: Farm Electricity

Topic 2: Electrical Wiring

Suggested Procedure and Activities: In addition to using the transparencies for this lesson, students should be shown the various tools and electrical wiring materials as each is discussed. Following the discussion and demonstration, it is suggested that each student make a test lamp to provide experience in soldering and taping. If available, Demonstration Board No. 3 illustrated in Reference No. 1 may be utilized to point out the various wiring materials.

1. Common Wiring Materials

Transparency No. 1

Wire Sizes

The size of conductor used for wiring is very important. A larger wire will safely carry more voltage, just as a larger pipe will carry more water than a smaller one with a given pressure. An attempt to force too much current over a small wire will increase the resistance and reduce the voltage, and the electrical devices will not function properly.

Electrical wires are numbered to indicate their size (gauge) according to the American Wire Gauge Standards. Small numbers indicate large wires, while large numbers indicate small wires.

There are two kinds of wire, solid and stranded. Stranded wire is made up of several small wires wrapped together. This provides more flexibility for the wire, particularly the larger sizes. Indoor wire larger than a No. 8 is generally stranded. A No. 6 stranded conductor is made up of seven smaller wires whose total cross-sectional area is the same as that of a No. 6 solid conductor.

Types of Wire - Outdoor wire is used for wiring between buildings and may be either copper or aluminum. Aluminum wire is lighter in weight and less expensive; however, one size larger wire is required to carry the same load in amperes as copper. Outdoor conductors are usually covered with neoprene or polyethylene.

The use of three-conductor self-supporting service drop wire has become common. It consists of two insulated wires wrapped around a bare stranded wire which is used as the ground and supporting wire.

The use of underground wire has increased in the last few years. These eliminate damage to the wire from ice storms and wind. The elimination of overhead wires also adds to the attractiveness of the farm.

Indoor wiring is designed for use inside buildings; however, some types can be used both inside and outside. Special coatings have been developed for areas inside buildings having excessive moisture. Most of the insulations used on inside conductors are made of fire and moisture resistant materials.

Transparencies Nos. 2a and 2b

Conduit - Where wires require mechanical protection, conduit should be used. Other advantages of using conduit are a greater choice of wire colors, the use of additional conductors, and added safety if the conduit is properly grounded.

Both flexible and nonflexible conduit are available. There are two kinds of nonflexible conduit, rigid and thin wall. Rigid has threaded ends and is much thicker. Thin wall is most often used for farm wiring. It is available in 10-foot lengths, is easily bent, and is mounted to steel boxes. Metal straps are used to support and keep it in place, and metal connectors and screw locks are used to fasten it to the boxes. The thin wall conduit may be cut with a 32-tooth hacksaw. A reamer or file is used to remove the rough edges on the inside of the conduit.

Care should be taken not to injure or reduce the size of the internal diameter when bending conduit. The conduit must be mounted before the wires are "fished" through it.

Outlet and Switch Boxes - These are installed at every switch, light, or junction point where wires are attached, with the exception of some outside wiring. Outlet boxes are usually octagonal or square. Switch boxes are made for flush or surface mountings.

Both octagon and square boxes are about the same size and measure four inches in diameter and 1 1/2 inches deep.

Flush mounted switch boxes are used in walls when the wire is concealed. Several types and depths of these boxes are available. The most commonly used box has beveled corners with clamps for nonmetallic cable. The sides are removable in order that more than one box can be ganged together to provide for a series of switches or receptacles at one location.

Surface - mounted switch boxes are made to fasten to an exposed surface. They receive wide use in barns and other outbuildings. Their corners are round but do not have clamps for nonmetallic cable. They can be used for conduit or cable wiring; but if nonmetallic cables are used, they should be the type that has a bare ground wire, which is used to ground the boxes.

To prevent possible damage to the wires, the number of wires of various sizes that may be permitted in boxes is specified by the code. The table below provides the number allowed for boxes of different sizes:

MAXIMUM NUMBER OF CONDUCTORS PERMITTED
IN OUTLET, SWITCH AND JUNCTION BOXES[1]

Trade Size of Box	Maximum Number of Conductors			
	No. 14	No. 12	No. 10	No. 8
4" octagon box, 1 1/2" deep	8	7	6	5
4" square box, 1 1/2" deep	11	9	7	5
Switch or handy box, 2" deep	5	4	4	
Switch or handy box 2 1/2" deep	6	6	5	
Switch or handy box, 3" deep	7	7	6	

[1]These numbers of wires apply if no cable clamps, fixture studs, switches, or receptacles are contained in the box. If the box contains cable clamps or fixture studs, the number of wires shall be reduced by one, with a further reduction of one wire if flush switches or receptacles are contained in the box. Each wire running through the box without splice is counted as one. Each wire terminating in the box is counted as one.

Receptacles - Several different types of receptacles are available. The ones shown in the transparency, as can be observed, are of the porcelain type.

Switches - Several kinds of switches are available. Three types are the single-pole, three-way, and four-way. These differ in number of terminals and in the number of places from which they can control lights.

Single-pole switches have two terminal screws and control lights in one location. Three-way switches have three terminals and control lights from two locations. Four-way switches have four terminals and are used in combination with three-way switches to control lights from three or more locations.

Duplex Receptacles - These are used to connect electrical equipment and appliances to a circuit. Receptacles for both 120-and-240-volt circuits, as well as the grounded type 120-volt, are available.

Blank Covers for Boxes - Blank covers are used to cover surface mounted boxes. Switch box covers are also available.

Wall Plates - Switches, duplex receptacles, and combination plates are available in bakelite, metal, glass, and other materials. Also, these are available in several different colors.

Connectors - Cables are fastened to boxes that do not have built-in cable clamps with cable connectors. These are available that will fit different sizes of knockouts in boxes.

The pressure-type split-bolt connector is used to connect outside wires to entrance wires.

Several kinds of solderless connectors are available. These are used to join wires inside junction boxes. One kind has a coil spring thread inside the cap which is turned into the pigtail connection to make and insulate it in one operation.

Ground Clamps - Two types of ground clamps are shown in the transparency. One is used to ground the electrical system to a ground rod, which is a copper rod 5/8 inches in diameter and about eight feet long. The other is for grounding the system to deeply buried water pipes.

Straps and Staples - These are used to fasten conduit and cables to the surfaces over which they run. There are numerous types available.

Insulators - Outdoor wires are supported by insulators. The racks are normally used for long spans, while screw knobs are placed in areas having a moderate amount of tension.

Entrance Elbow or Sill Plate - Either one of these may be used where conduit or entrance cable enters the building. A removable cover on the elbow aids in installing the wires. The sill plate fits around the entrance cable where it enters the building.

2. <u>The Wiring System</u>

Any well-planned wiring system must be safe, economical, adequate, and expandable. Conductors used in the system should be of a size that will carry the necessary amperage safely. They must be fused properly and installed according to the National Electric Code. Safety is acquired when the code is followed. The other factors depend upon careful planning.

An economical system is one that is safe, adequate, and efficient and was acquired at a minimum cost.

For a system to be adequate, it should have sufficient voltage to operate all appliances with no more than a two percent voltage drop for lighting and heating appliances. There should be no more than a three percent voltage drop for motors. An adequate number of outlets and switches of the proper type and rating should be included in the system. Also, anticipated future electrical needs should be considered and allowances made for their installation.

3. Common Splices and Connections

Improper splices and connections may not provide dependable electrical service and can be a very serious fire hazard or life safety factor. The three basic splices are the western union, center tap, and rat tail.

Transparencies Nos. 3a and 3b

Western Union - This splice is used when strength is required in the splice, such as running a wire from one building to another. Enough insulation is removed from the wires to be spliced to allow five or six turns of the wire. If the insulation is removed with a knife, it is cut at a slant to prevent the cutting of the wire, which could reduce its strength. Combination wire cutters and strippers are available. These are adjustable and can be used on a number of different wire gauges without damage to the wire. To begin the splice, each of the wires is bent into a 90-degree angle about one inch from the insulation. The wires are crossed and one wire is wrapped around the other wire. Pliers may be used to smooth the sharp edges. The splice is now ready for soldering and taping, which will be discussed later.

Center Tap - The tap splice is used to branch off of a wire and go in another direction. Since this splice has very little strength, an insulation should be used to anchor the wire. About two to 2 1/2 inches of insulation is removed from the main wire. The tap wire is bent into a 90-degree angle about one inch from the insulation on the center tap. The tap wire is placed in the center of the main wire, and seven or eight wraps are made around the main wire.

Rat Tail Splice - This type is used in junction boxes where the conductors are clamped in the box. This splice has very little strength.

Attention is called to the proper connecting of conductors to terminals. The loop should be attached to the terminal in the direction in which the screw turns.

Transparency No. 4

Soldering Splices - To solder the western union splice, the wires are first coated with an electric soldering paste. If rosin core solder is used, it may not be necessary to use a soldering paste. The heated soldering iron is held on the underside and against the wire until the wire will melt the solder. Solder is flowed into every crevice in the wire.

The center tap and rat tail splices may be soldered in the same manner as the western union splice. Another method of soldering the rat tail splice is to dip it into a ladle filled with molten solder.

Applying Tape - At one time, two kinds of tape were used for taping splices. The splice was taped first with a rubber tape and then friction tape was used to cover the rubber tape. The plastic tape available today is the only tape needed. It is faster, neater, cleaner, and is water-and acid-proof.

To start a splice, the tape is extended about 3/4 of an inch over the insulation on one end. Each lap is extended one-half the distance of the previous wrap. The tape is kept tight as each wrap is made and is wrapped about 3/4 of an inch over the insulation on the opposite end. Two complete wrappings over the splice result in four thicknesses of tape. Two wraps are usually sufficient for proper insulation.

Transparency No. 5

Solderless Connectors - These may be used instead of soldering and taping. Size of wire, type of wire, and location of connection will influence the connector to use for a specific job.

4. Types of Switches

Transparency No. 6

Simple Switches - A simple switch (single pole-single throw) controls a circuit from one location. Toggle, mercury, silent, rocker button, and push button are the types available. The thermostat and humidistat are two types of single pole switches operated by mercury. A single pole switch has two terminals (screws) and two positions, open and closed. Switches are never installed in a neutral line.

Transparency No. 7

The wiring diagram illustrates how a single pole-single throw switch is connected in a circuit to control a light. With the switch in the fuse box in the closed position, the flow of current can be traced to the switch, through the switch when switch is closed, through the light, and back to the source on the neutral wire.

Transparency No. 8

Three-Way Switches - A three-way switch is referred to as a single pole - double throw switch, and is used to control a circuit from two locations. Three-way switches have three terminals (screws). The single terminal on the side of the switch is called the common terminal, while the two terminals on the opposite side are called traveler terminals.

The operating principles and wiring diagram of three-way switches are illustrated in the above transparency. To install two three-way switches, the hot wire from the power source is connected to the common terminal of one of the switches. Each of the traveler terminals of one switch is wired to the traveler terminals of the other switch. The common terminal of the remaining switch is connected to the hot lead of the light. The neutral lead on the light is connected to the neutral wire.

The current flow can be traced from the hot wire and through the circuit to show that either switch will turn the light on or off.

Transparency No. 9

Four-Way Switches - These are used between three-way switches to provide additional points of control for a circuit. They are wired to the two traveler wires of the three-way switches.

The wiring diagram illustrates the operating principle of a four-way switch and the connections that are made. The traveler wires between the two three-way switches are cut and attached to the terminals of the four-way switch and are wired to feed straight through the four-way switch.

The current flow can be traced from the hot wire source and through the circuit to show that either switch will turn the light on or off. The two positions of the four-way switch will feed straight through or diagonally.

5. Installing Lighting and Outlet Circuits

The wiring diagrams that have been used to illustrate the various connections have not shown the wiring, boxes, outlets, and controls as they must be actually installed. It is important that each student have an opportunity to practice the installing of lighting and outlet circuits.

Transparencies Nos. 10 and 11

The wiring demonstration board may be used to provide student practice. All connections and splices should be made in boxes. The wire used and all installations should be the same as would be used and made in a building.

No. 14 romex with ground wire should be used for the outlet circuit. No. 14 three-wire romex should be used between the three-way switches. White insulated wires used for hot wires should be marked in each box with black plastic tape. Solderless connectors should be used to make the splices. Demonstrate stripping romex and removing the insulation from wires prior to installation.

It is suggested that the teacher use transparency No. 10 and draw the wiring diagram. Also, students should draw the wiring diagram before actually performing the skills required to wire the demonstration board. The teacher may wish to duplicate the master for transparency No. 10 to give students practice in drawing the wiring diagram. Symbols used in drawing wiring diagrams are shown in the above transparency.

Outlet Circuit - After stripping the romex and removing the insulation from the black and white wires, place the romex into the fuse box and connect the black wire to the terminal below the fuse. Connect the white and bare wires to the neutral bar. Place the other end of the romex through the first outlet box, strip and remove the insulation. Connect the black wire to the brass screw, the white wire to the silver screw, and the bare wire to the safety-ground (green) screw. Using the same color coding, connect the first outlet to the second outlet with another length of romex. Install outlets and place covers on outlet boxes.

Lighting Circuit and Two-Way Switch - Place No. 14 two-wire romex in the fuse box. After stripping and removing the insulation, connect the black wire to the terminal below the fuse and the white wire to the neutral bar. (If romex with safety-ground is used, connect the bare wire to the neutral bar.)

Carry the other end of the romex into the first junction box, strip and remove the insulation.

Using another length of two-wire romex, place one end into the junction box and the other end into the first switch box. (Mark white wire with black tape in each box.)

Another length of two-wire romex should be run from the first junction box to the second junction box for the three-way switch installation.

In the first junction box, the following splices should be made: (1) Black wire from fuse box, white wire with black tape, and black wire going to second junction box. (2) Black wire from switch box and black lead of light. (3) White wire from fuse box, white lead of light, and white wire going to second junction box. (If safety-ground wire is used, connect it to screw of junction and/or switch boxes.) Place the porcelain light fixture on the junction box for the cover and to mount the fixture.

Two-Way Switches - Connect the black wire to one terminal and the white wire to the other terminal. Install switch and cover.

Three-Way Switches - Using three-wire romex, run a length from the junction box to one switch box and a separate length from the junction box to the other switch box.

In the three-way switch boxes, connect the black wire of the three-wire romex to the common terminal and the red and white wires to the traveler terminals. The white wires should be marked with black tape.

In the second junction box, make the following splices: (1) Black wire from first junction box and black wire from one three-way switch. (2) Black lead of light and black wire from the second three-way switch. (3) Red traveler wires. (4) White traveler wires (marked with black tape). (5) White wire from first junction box and white lead of light.

Mount the porcelain light fixutre on the junction box and install three-way switches and covers.

Energize the fuse box and check the circuits and switches to determine if they function properly. Note: Since the safety-ground wire is used, it is most important that the circuit be polarized when energized. Polarizing the circuit means that the neutral wire is connected to the neutral wire of the circuit board.

6. Planning the Farm Wiring System

Transparency No. 12

The farm wiring system includes both exterior and interior wiring, and extends from the point of supply to various outlets located inside and outside of farm buildings. A well-planned wiring system can pay the farmer dividends by reducing the size of wire, size of electrical equipment needed, amount of wire used, installation labor, and the amount of electricity used.

A procedure that may be used in planning a farm wiring system is given below:

1. Prepare a farmstead plan.
   a. Buildings are drawn to scale (size and respective location of buildings).
   b. Present power supply source is included.
2. Determine number of circuits needed in each building.
   a. Plan is prepared for each separate building.
   (A residence is used as an example.)
      (1) General purpose circuits
         (a) The number of outlets needed is determined by taking the floor plan and spacing at least one convenience outlet for every 12 feet of wall space. This spacing provides a circuit for any appliance having an extension cord six feet long. No more than eight convenience or lighting outlets should be on one circuit, and this number is too many for the kitchen. An adequate number of lighting outlets should also be determined. The number and size of light fixtures is determined by the amount of floor space in a given area and the amount of candle power of the fixture.

Although there is some difference in the number of outlets needed in a residence and other farm buildings, a number of convenience outlets are required in most farm buildings.

(b) Because of the high wattage of many kitchen appliances, at least two general purpose circuits should be provided in this area.

(c) Number 12 wire is used for general purpose circuits, and the circuits are protected with 15 or 20 ampere fuses or circuit breakers.

(2) Special Purpose Circuits

(a) These are provided for appliances such as range, water heater, air conditioner, food freezer, water system, and clothes dryer. The size of wire used in special circuits is based on safe ampere capacity and permissible voltage drop.

(b) Graphical electric symbols are placed on the building floor plan to indicate 120-volt outlets, 240-volt outlets, etc.

(c) Select service entrance panel.

(1) The service entrance cables and service equipment are capacity rated and should have a rating that is adequate to handle the electrical load safely. A farm home with central heat and air conditioning may require equipment with a capacity to handle as much as 200 amperes.

(2) A distribution panel with 20 to 24 branch circuit positions is recommended for the home. Some of the branch circuit positions that may be required in a residence are given below:

BRANCH CIRCUIT POSITIONS NEEDED

Electric Range (240 v)	2
Clothes Dryer (120/240 v)	2
Water Heater (240 v)	2
Automatic Washer (120 v)	1
Freezer (120 v)	1
Appliance Circuits (120 v)	2 (est)
Water Pump (120 or 240 v)	1 or 2
Lighting Circuits (120 v)	4 (est)
Fuel-Fired Heating System (120 v)	1
Dishwasher (120 v)	1
Waste Disposer (120 v)	1
Air Conditioner (240 v)	2
Spares	2 or 3
	24

The "Agricultural Wiring Handbook," a reference for this topic, can be used in planning the wiring layout in other buildings.

3. Consult power supplier to determine the location of the meter (pole or building).

   The meter pole should be located in an area that is accessible to power supplier, but not in an area that will interfere with the operation of the farm. Normally, the meter is centrally located from the standpoint of electrical load. It is possible that the meter location can reduce wiring expenses by reducing the wire size used in feeder circuits to buildings.

4. Select feeder circuit wire sizes
   The "Agricultural Wiring Handbook" can be used in making these selections.

5. Consult with power supplier on "meter loop" requirements.

References:

1. "Farm Electrification Lesson Plans - Wiring and Safety", Texas Education Agency and Vocational Instructional Services, Texas A&M University, College Station, Texas, 1973.

2. "Agricultural Wiring Handbook", Food and Energy Council, Inc. , 909 University Ave., Columbia, Missouri, 1978.

3. "Electrical Wiring - Fundamentals and Planning", Vocational Agriculture Service, University of Illinois, Urbana, Illinois, 1970.

4. "Electrical Controls and Basic Control Circuits Used In Agricultural Production", Texas Education Agency and Vocational Instructional Services, Texas A&M University, College Station, Texas, 1973.

5. "Simplified Electric Wiring Handbook", Sears Roebuck and Company.

Allowable Current-Carrying Capacities

of

Insulated Copper and Aluminum Conductors in Amperes

Size AWG or MCM	A				B			
	Not More Than Three Conductors in Raceway or Cable, or Direct Burial				Single Conductors in Free Air			
	1		2		3		4	
	Rubber Insulation, Type R, RW, RU, RUW Type RH-RW in Wet Locations Thermoplastic Insulation, Type T, TW		Rubber Insulation, Type RH, RHW Type RH-RW in Dry Locations		Weatherproof Insulation, Type WP		Thermoplastic Insulation Type TW	
	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum
14	15	--	15		xx	xx	xx	xx
12	20	15	20	15	xx	xx	xx	xx
10	30	25	30	25	55	45	40	30
8	40	30	45	40	70	55	55	45
6	55	40	65	50	100	80	80	60
4	70	55	85	65	130	100	105	80
3	80	65	100	75	150	115	120	95
2	95	75*	115	90*	175	135	140	110
1	110	85*	130	100*	205	160	165	130
0	125	100*	150	120*	235	185	195	150
00	145	115*	175	135*	275	215	225	175
000	165	130*	200	155*	320	250	260	200
0000	195	155*	230	180*	370	290	300	230
250	215	170	255	205	410	320	340	265
300	240	190	285	230	460	360	375	290
350	260	210	310	250	510	400	420	330
400	280	225	335	270	555	435	455	355
500	320	260	380	310	630	490	515	405
600	355	285	420	340	710	560	575	455
700	385	310	460	375	780	615	630	500
750	400	320	425	385	810	640	655	515

If bare conductors are used with insulated conductors, their allowable current-carrying capacity shall be limited to that permitted for insulated conductors of the same size.

* For three-wire, single-phase service and sub-service circuits, the allowable current-carrying capacity of RH, RH-RW, RHH, and RHW aluminum conductors shall be for sizes No. 2-100 amp, No. 1-110 amp, No. 1/0-125 amp, No. 2/0-150 amp, No. 3/0-170 amp, and No. 4/0-200 amp.

xx No. 10 is minimum permissible in overhead spans up to 50 ft. in length. For spans over 50 ft. in length, No. 8 is minimum permissible. See 1956 NE code, Section 7314b.

CONDUCTORS - SIZE & TYPE

ACTUAL SIZE OF WIRE

OUTDOOR WIRE TYPES — USES

UF	- underground feeder	Buried underground
USE	- underground service entrance	Mechanical protection required where they enter and leave ground
SE or SEU	- service entrance unarmored	To bring current into buildings
ASE	- armored service entrance	Same as SE

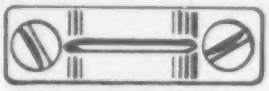
INDOOR WIRE TYPES — USES

T	- thermoplastic	Inside buildings
TW	- thermoplastic moisture resistant	In areas with moisture
RH	- rubber, heat resistant	Carry higher voltage than T or TW
RHW	- rubber, heat and moisture resistant	Service entrance or large appliance
NM	- nonmetallic cable (romex)	Inside buildings

WIRING MATERIALS

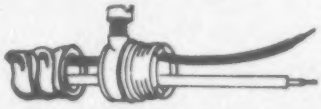
FLEXIBLE CONDUIT

THINWALL or RIGID CONDUIT

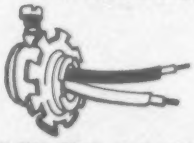


CONDUIT STRAP

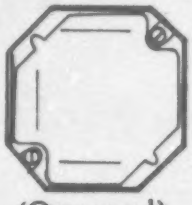
CONDUIT CONNECTOR



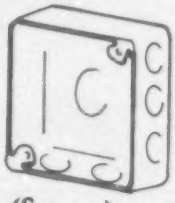
CONNECTOR



SCREW LOCK

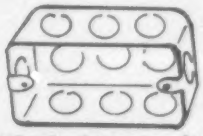


(Octagonal)

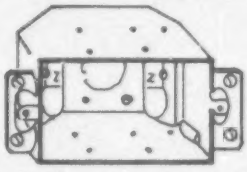


(Square)

OUTLET BOXES

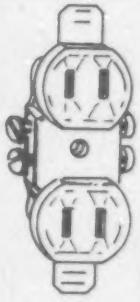


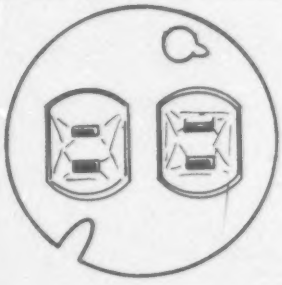
(Flush Mounted)



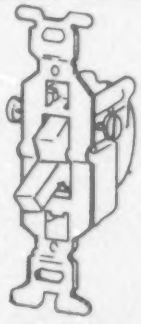
(Surface Mounted)

SWITCH BOXES

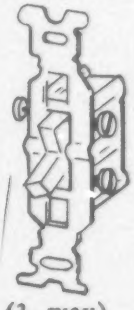




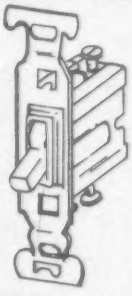
DUPLEX RECEPTACLES



(Single Pole)

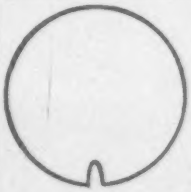


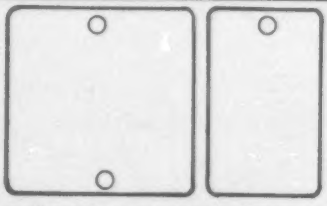
(3-way)



(4-way)

TOGGLE SWITCHES



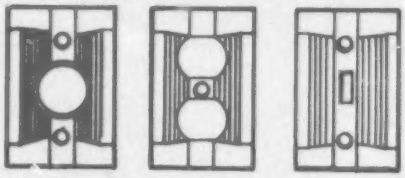


BLANK COVERS FOR BOXES

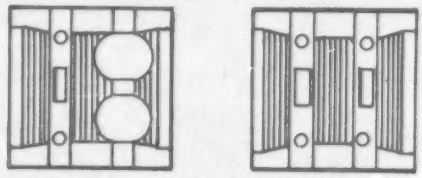
(Keyless) (Pull-chain) (Pull-chain w/outlet)

PORCELAIN RECEPTACLES

WIRING MATERIALS

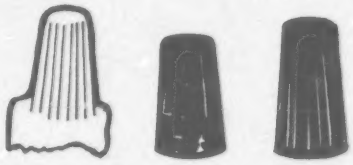


WALL PLATE COVERS

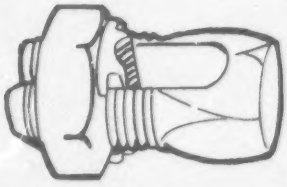


MULTIPLE GANG PLATES

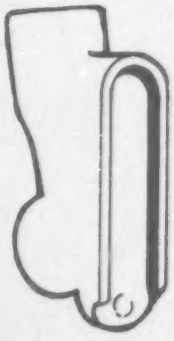
CABLE CONNECTORS



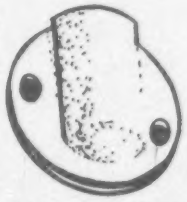
SOLDERLESS CONNECTORS



SPLIT BOLT CONNECTOR

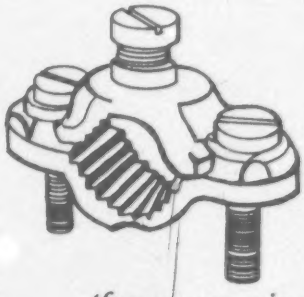


ENTRANCE ELBOW



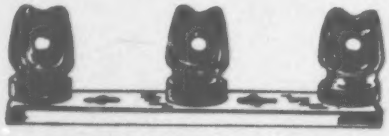
SILL PLATE

(for ground rod)



(for water pipe)

GROUND CLAMPS

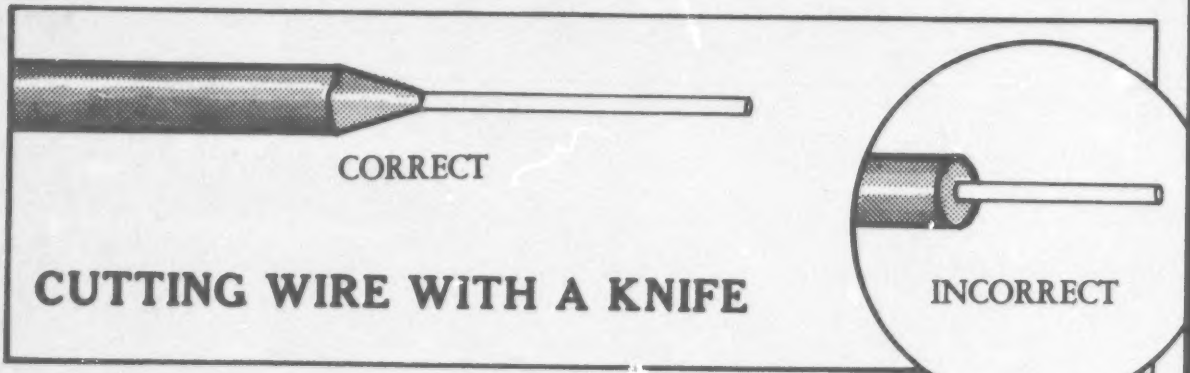


INSULATOR RACK

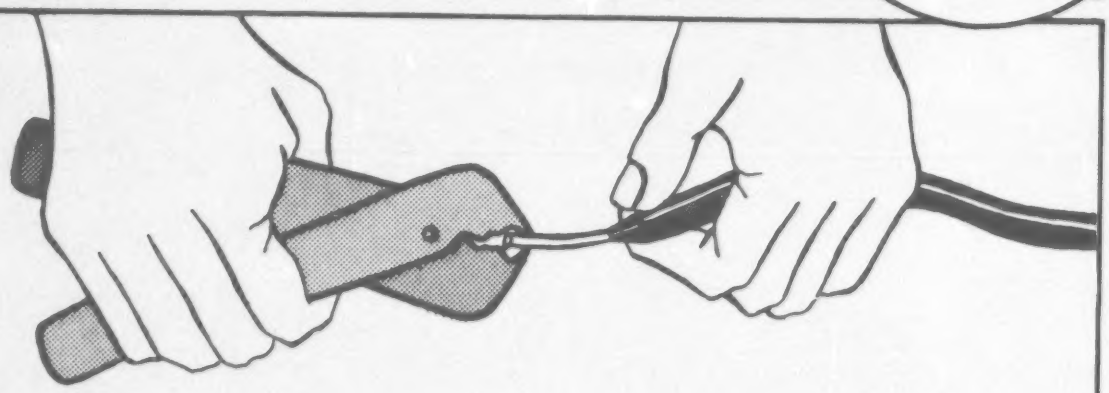
Screw Knob

STRAPS & STAPLES

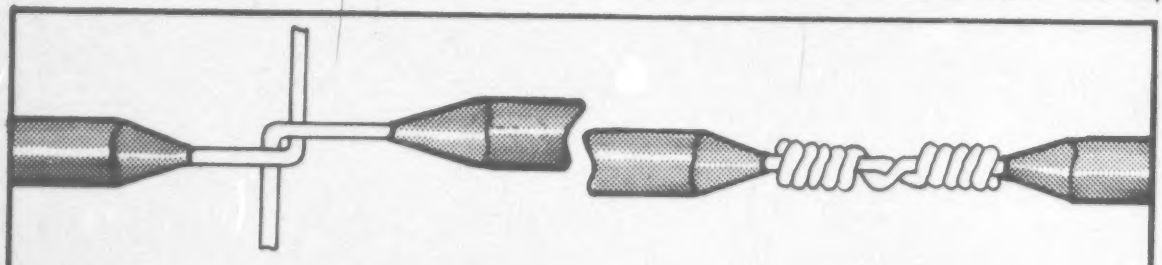
SPLICING



CUTTING WIRE WITH A KNIFE

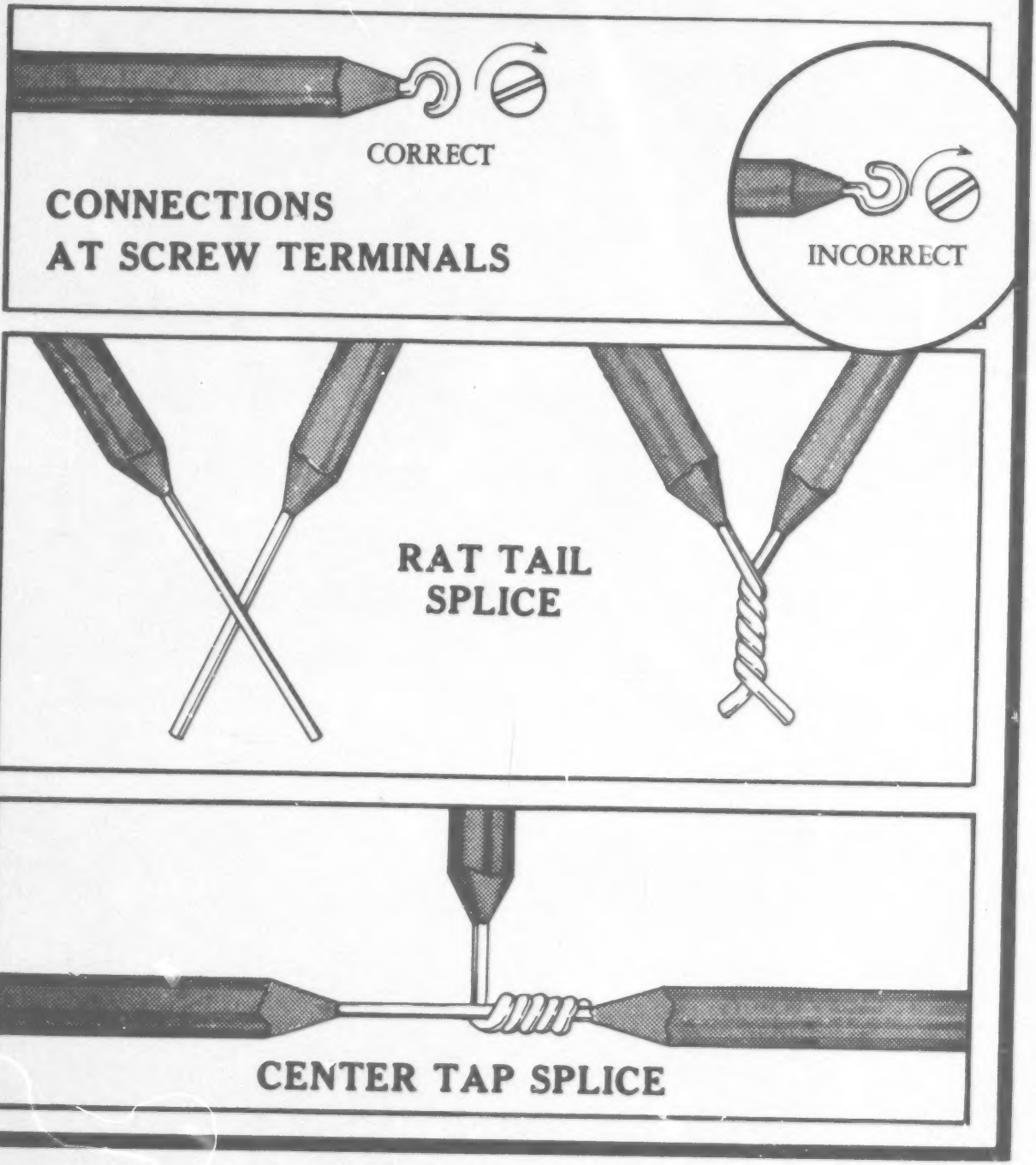


COMBINATION WIRE CUTTER AND STRIPPER

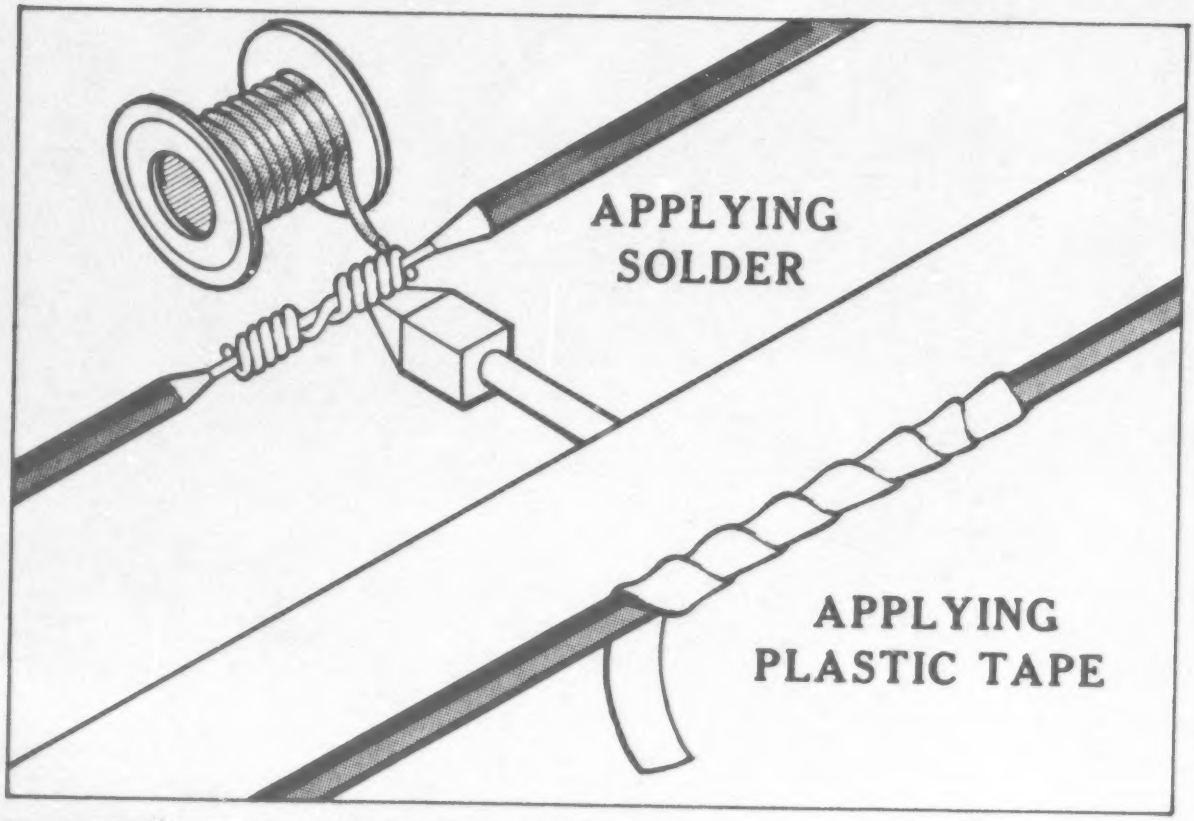


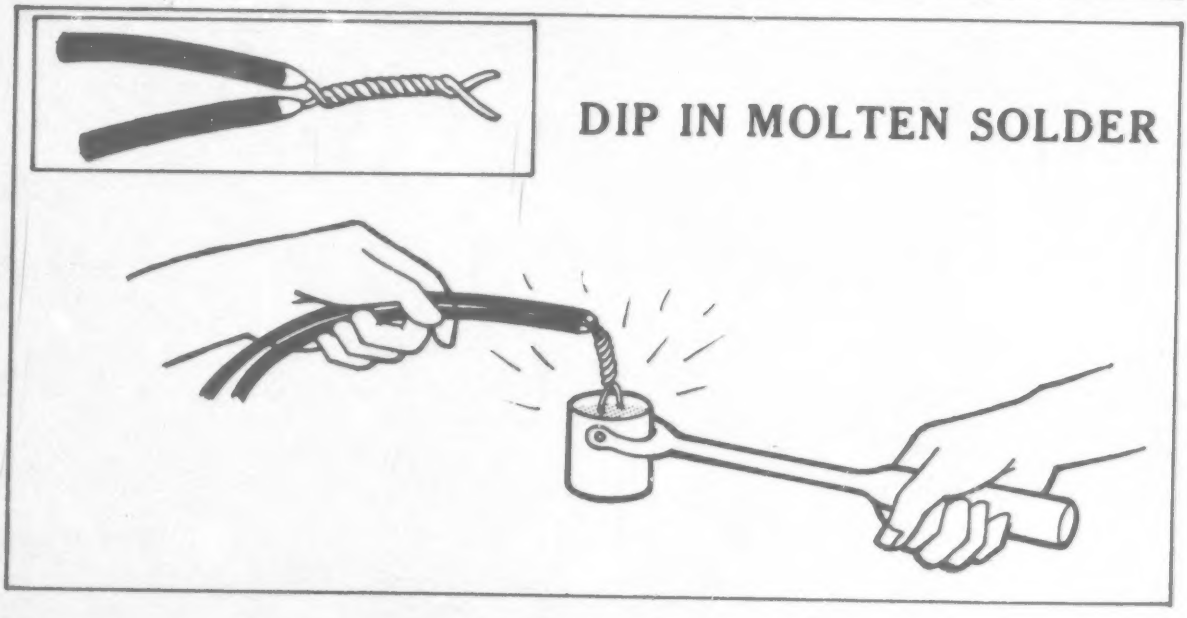
WESTERN UNION SPLICE

SPLICING


CORRECT
CONNECTIONS
AT SCREW TERMINALS
INCORRECT
RAT TAIL
SPLICE
CENTER TAP SPLICE

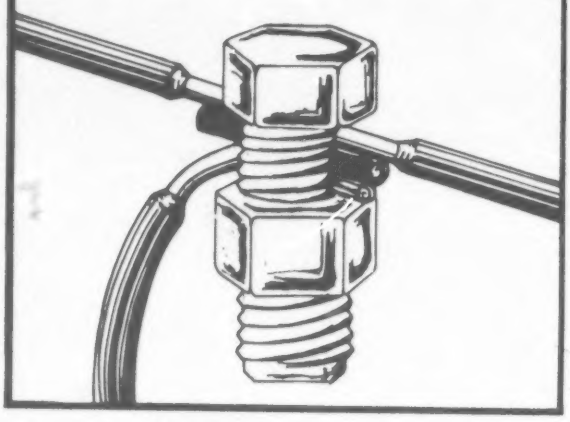
SOLDERING & TAPING

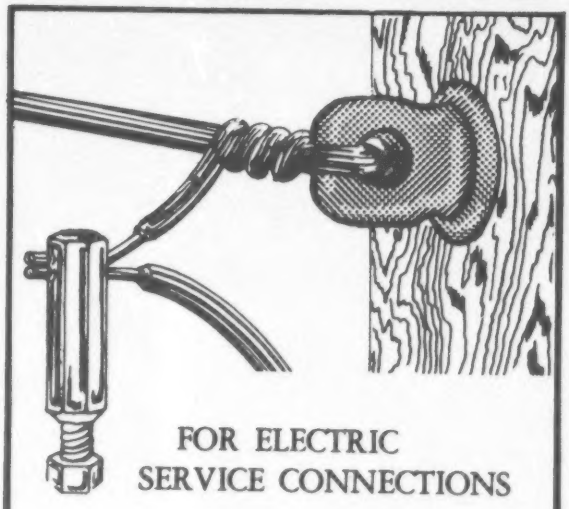




SOLDERLESS CONNECTORS

TAPS EXISTING LINE WITH STRAIN ON WIRES

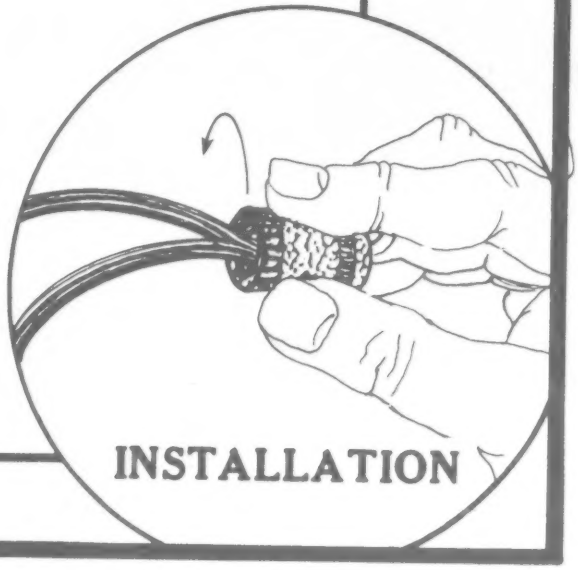




FOR ELECTRIC SERVICE CONNECTIONS

MADE OF INSULATING MATERIAL

CUT-AWAY VIEW



INSTALLATION

SIMPLE SWITCHES

SINGLE POLE - SINGLE THROW

TOGGLE - MERCURY - SILENT

ROCKER BUTTON - PUSH BUTTON

THERMOSTAT

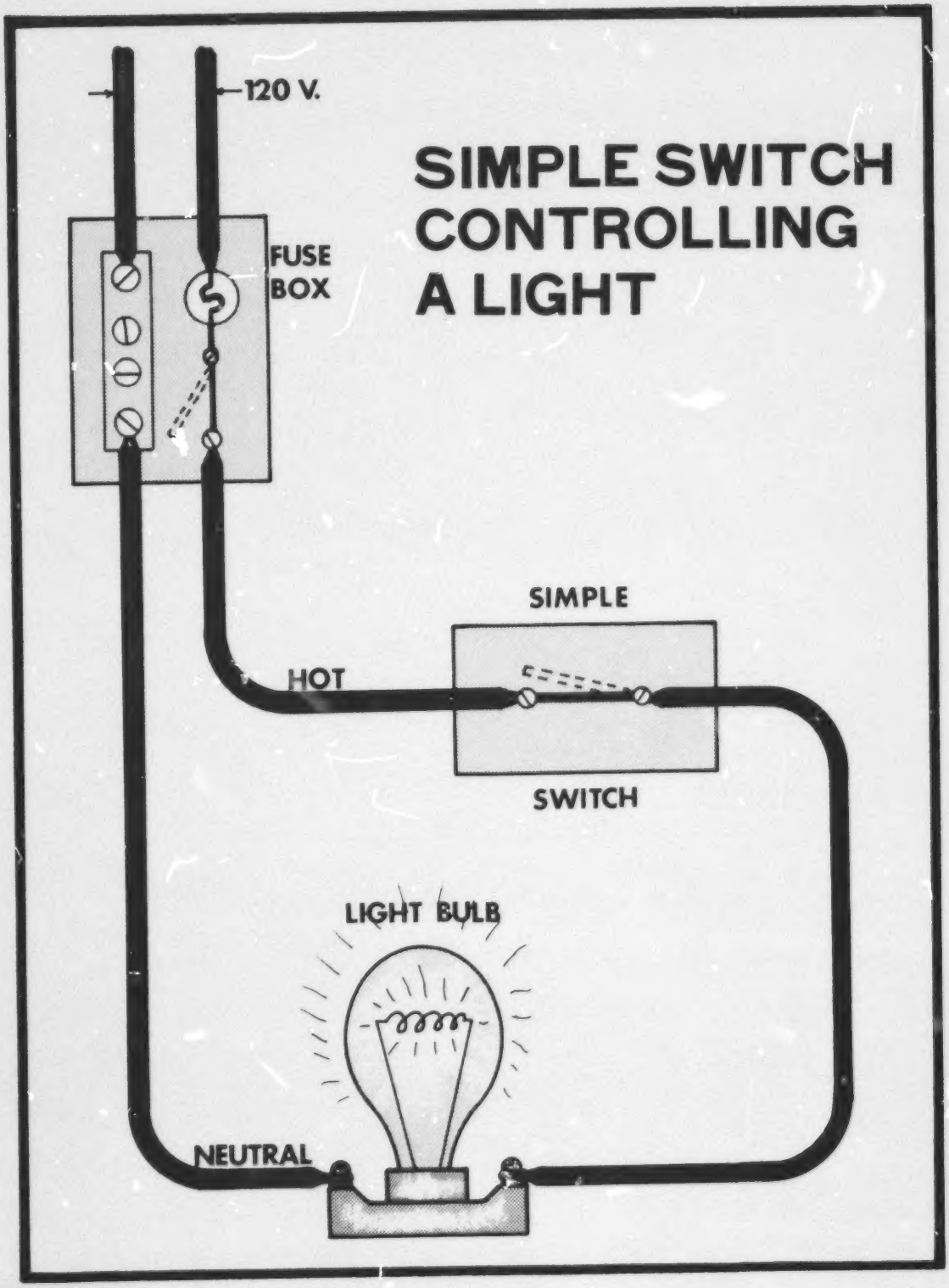
HUMIDISTAT

SIMPLE SWITCHES CONTROL THE CIRCUIT FROM ONE LOCATION

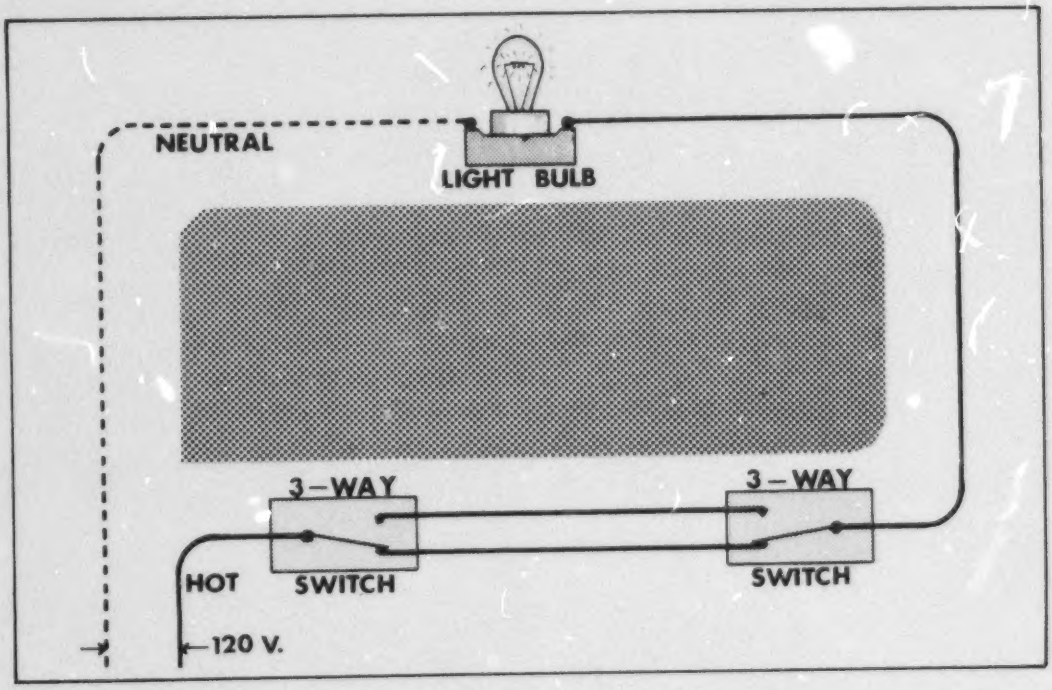
SIMPLE SWITCHES HAVE TWO POSITIONS - OPEN OR CLOSED

SIMPLE SWITCHES ARE NEVER INSTALLED IN A NEUTRAL LINE

SINGLE POLE SWITCHES HAVE TWO SCREWS


120 V.
SIMPLE SWITCH CONTROLLING A LIGHT
FUSE BOX
SIMPLE
HOT
SWITCH
LIGHT BULB
NEUTRAL

THREE-WAY SWITCH



SINGLE POLE - DOUBLE THROW

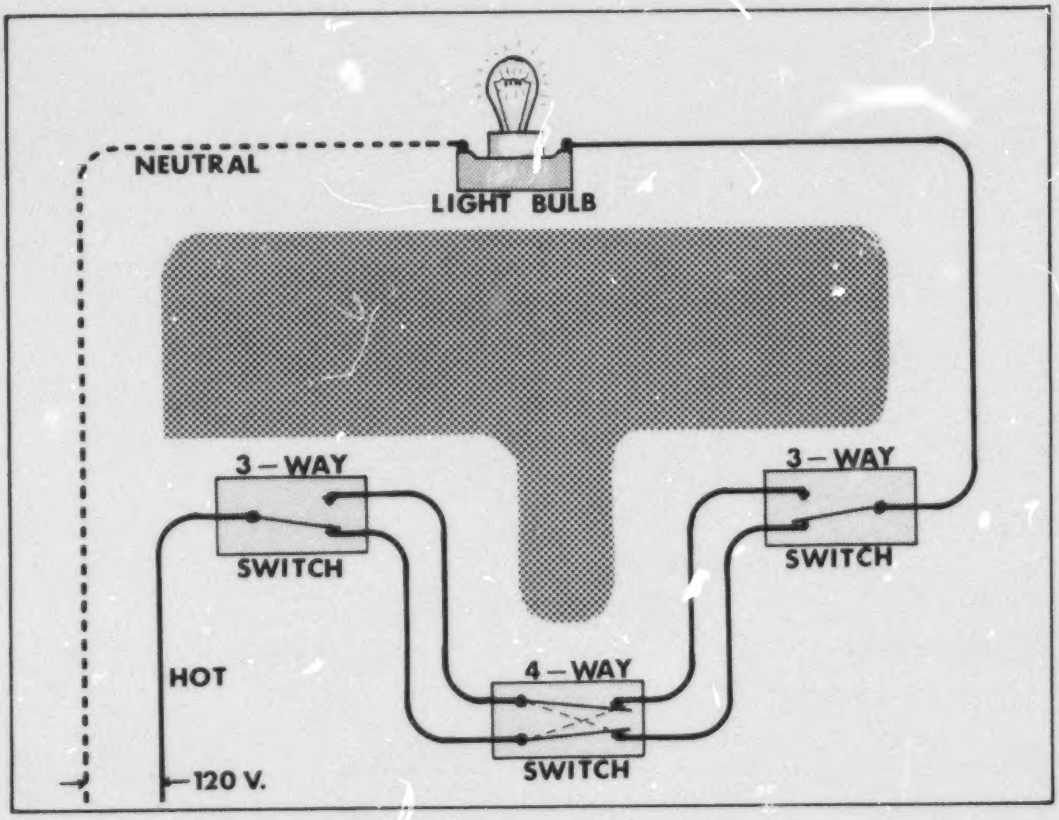
THREE SCREWS ON THE SWITCH:

One screw - common or pivot terminals

Two screws - traveler terminals

USED TO CONTROL CIRCUIT FROM TWO LOCATIONS

FOUR-WAY SWITCH

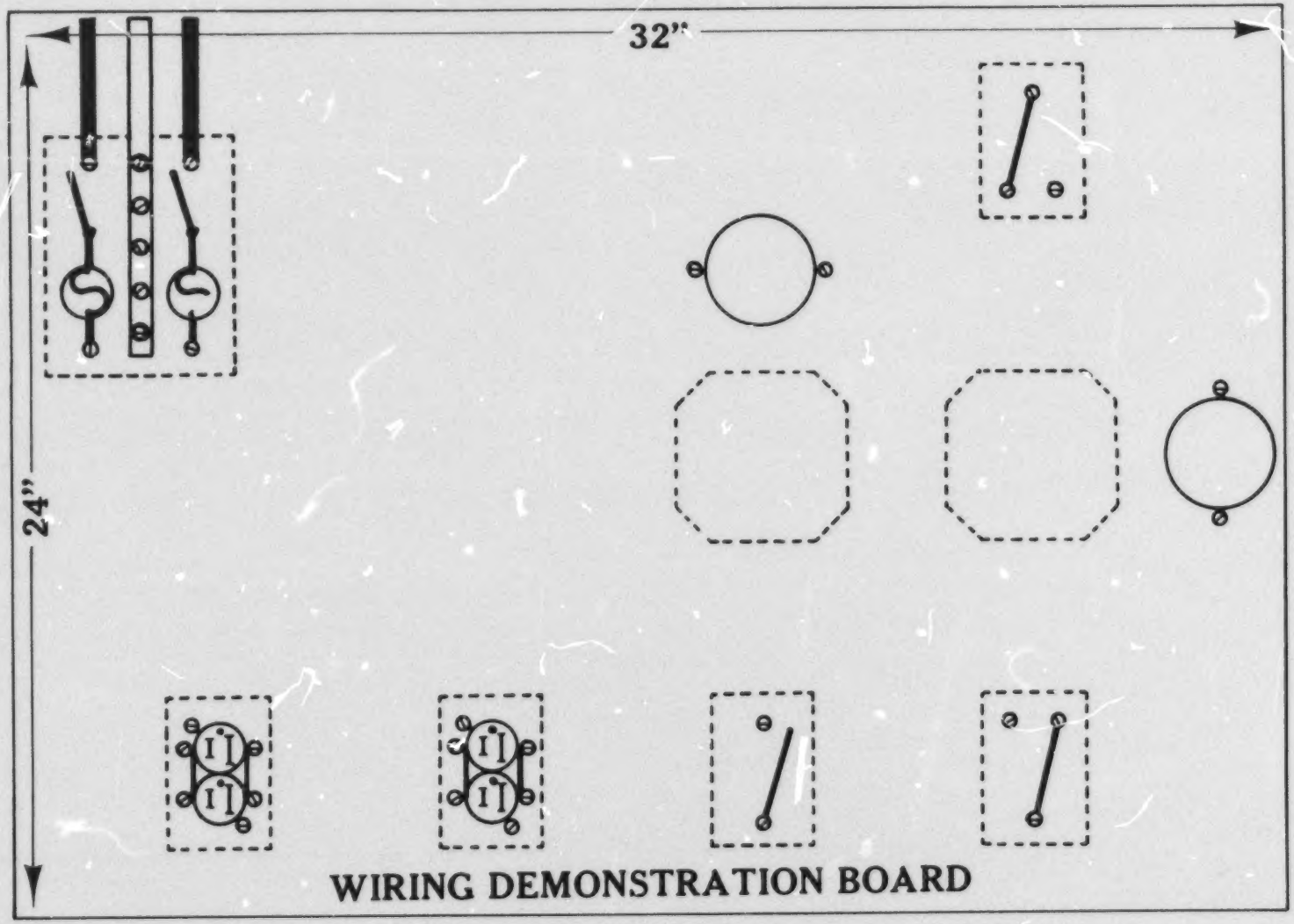


FOUR SCREWS OR TERMINALS

USED BETWEEN TWO THREE-WAY SWITCHES TO CONTROL CIRCUIT FROM ANOTHER LOCATION

INSTALLED IN TWO TRAVELER WIRES OF THE THREE-WAY SWITCHES

WIRING LAYOUT



WIRING DEMONSTRATION BOARD

ELECTRICAL SYMBOLS

GENERAL OUTLETS

Lighting Outlet

Ceiling Lighting Outlet for Recessed Fixture (Outline Shows Shape of Fixture.)

Lighting Outlet with Lamp Holder

Lighting Outlet with Lamp Holder and Pull Switch

Fan Outlet

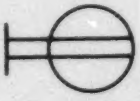
Junction Box

Drop-Cord Equipped Outlet

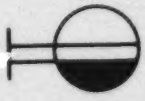
Clock Outlet

To Indicate Wall Installation of Above Outlets, Place Circle Near Wall and Connect with Line as Shown for Clock Outlet.

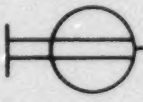
CONVENIENCE OUTLETS


Duplex Convenience Outlet (Grounding Type Outlet Required)

Triplex Convenience Outlet (Substitute Other Numbers for Other Variations in Number of Plug Positions, Such as 1 for Single Convenience Outlet)


Duplex Convenience Outlet-Split Wired

Weatherproof Convenience Outlet


Combination Switch and Convenience Outlet

Floor Outlet

Range Outlet

Special-Purpose Outlet. Use Subscript Letters to Indicate Function. DW-Dishwasher, CD-Clothes Dryer, etc.

SWITCH OUTLETS

S Single-Pole Switch

S_2 Double-Pole Switch

S_3 Three-Way Switch

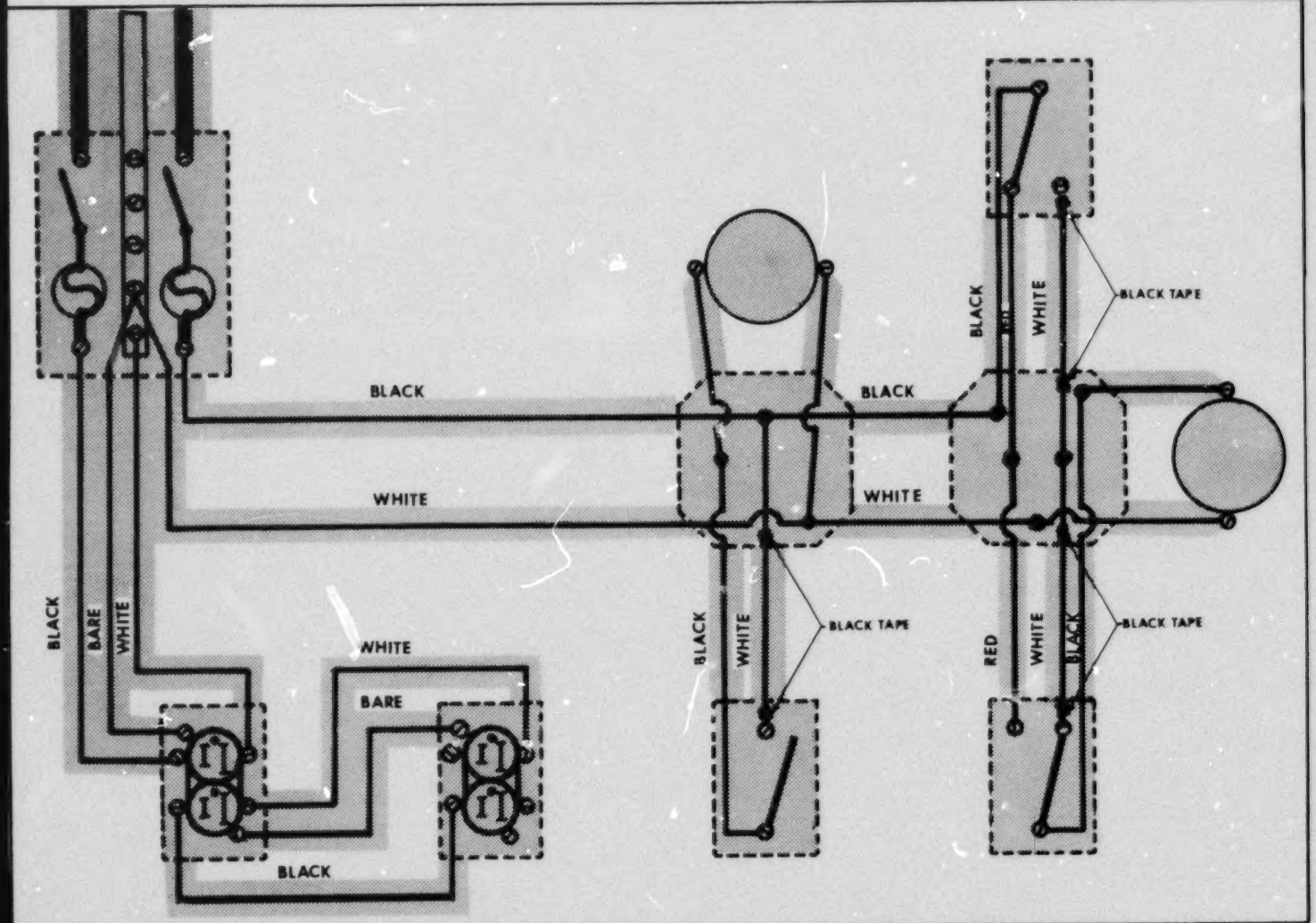
S_4 Four-Way Switch

S_{WP} Weatherproof Switch

S_D Automatic Door Switch

S_P Switch and Pilot Light

WIRING LAYOUT



CONSTRUCTION AND MAINTENANCE

Unit D: Farm Electricity

Topic 3: Types and Uses of Electric Motors

Suggested Procedure and Activities: It is suggested that the different types of motors be displayed and used during the presentation of the topic. Demonstrating the use of the continuity test lamp should assist students in understanding the operating principles and installation procedures of electric motors.

1. Advantages of Using Electric Motors

The use of electric power on the farm is steadily increasing. The reasons for this increase are the many advantages offered by electric power:

Transparency No. 1

1. Inexpensive to Operate - An electric motor can work continuously. A 1/4 horsepower (Hp) motor can do the physical work that two men can accomplish. (The cost of operating electric motors may be reviewed.)

2. Always Ready to Work - Temperature extremes and changes have little effect on motor starting or operation.

3. Efficient - Compared to other power sources, the electric motor is one of the most efficient. The efficiency of electric motors will vary from 65 to 90 percent.

4. Long Life - Having few moving parts with little to wear out enables a motor to last many years with proper care.

5. Simple to Operate - No special skills or experience are required to operate electric motors. They can be started and stopped by a simple switch.

6. Safe - Electric motors are safe if properly installed. They require no inflammable fuel and produce no dangerous flames or fumes. They have no open gears and require no physical labor to be started.

7. Minimum Servicing - Electric motors require a minimum of attention - no fuel to carry, no oil to change, or battery to change.

8. Quiet Operation - Operate quietly and smoothly with very little vibration.

9. Compact and Easily Automated - Require little space and can be automatically and remotely controlled.

10. Adaptable - Electric motors are light and can be easily moved. They are adaptable to different operating positions and conditions.

2. Factors to Be Considered in Selecting Electric Motors

A number of factors should be considered when selecting electric motors for a specific job. A list and discussion of these factors are as follows:

Transparency No. 2

1. Type of Power Available - The type of electric service available is important because a 230-volt motor should not be selected if only 115-volt circuits are available. Also, a three-phase motor cannot be operated on an electrical system that has only single-phase service. Most of the common motors discussed here will be single-phase, single voltage (115-volt) or dual voltage (115 or 230-volt) motors.

2. Size of Motor - The size of electric motors is rated in horsepower. The rating given to a motor refers to the power that it will develop when the motor is turning at full speed. The "rules of thumb" used for estimating the size of motor needed are (1) If the equipment can be operated by hand, an 1/4 Hp motor will usually be adequate, and (2) If a gasoline engine is to be replaced by an electric motor, an electric motor approximately 2/3 the Hp rating of the engine will usually be adequate.

3. Starting Load - The motor selected must have the starting torque or turning force to start the load. Various motors have different methods of starting and different starting torques. Based upon the method of starting, there are seven types of motors:

    1. Split-Phase
    2. Capacitor-Start
    3. Split-Capacitor Start
    4. Repulsion Start
    5. Series or Universal
    6. Shaded Pole
    7. Three-Phase

    The characteristics and common uses of these motors will be discussed later in this lesson.

4. Speed Requirement - Electric motors are rated at the speed the shaft will turn in revolutions per minute (rpm) when the motor is operating at full speed. The rpm of the motor should be the speed needed to operate the equipment at the proper speed.

5. Type of Bearings - Electric motors may have sleeve bearings or ball bearings. Motors with ball bearings will normally require less maintenance and can be mounted in any position.

6. Type of Base - The motor may need a rigid base, a sliding base that is adjustable, or a cushion mount to reduce vibration and wear.

7. Environment - The type of motor enclosure (frame) should be selected to provide proper protection to the motor from its surroundings - primarily protection from dust, dirt, and water. The three common types of enclosures available are (1) Open-Dripproof, (2) Splashproof, and (3) Totally Enclosed.

3. Nameplate on an Electric Motor

The nameplate on an electric motor provides information that will assist a person in selecting the proper motor for the job, in making the installation, and in energizing the motor with the proper voltage. An explanation of each part of the nameplate is given below:

Transparency No. 3

A.C. - 1 PH. - This indicates the motor will operate on alternating current and single phase power.

Motor Type - This refers to the model or motor type as designated by the manufacturer.

Thermoguard Type - The motor has a built-in protection device to protect it from too many amperes. The thermal relay opens the circuit when the ampere flow becomes high enough to endanger the motor windings. The thermal relay may close automatically after it cools, or it may be the manual-reset type that requires an operator to push the reset button each time the thermal relay opens.

HP-1/2 - The motor is rated at 1/2 horsepower.

R.P.M. - 1725 - The motor shaft turns 1725 rpm when pulling its rated load.

Cycle - 60 - The motor is to be used on 60-cycle current. (HERTZ)

^{0}C - 40 - This indicates the temperature rise in the windings when the motor operates at rated load and voltage under normal conditions.

Hours - Cont. - This motor is designed to operate continuously, while some are designed to operate intermittently.

Volts - Amps - The voltage on which the motor will operate is designated. If it is a single-voltage motor, only one voltage rating will be designated. A dual-voltage motor will have both voltages shown, as in the illustration. The number of amperes is shown under each voltage and is to be considered the ampere rating of the motor at its rated load. Note that the ampere rating at 240 volts is exactly one-half the ampere rating when wired with 120 volts. Smaller conductors may be used for motors operating on 240 volts because only one-half the amperes are carried on each wire.

The proper wiring diagram of the terminal block should be followed for the voltage to be used.

This motor can be reversed (rotate shaft in opposite direction) by interchanging the red and yellow leads on the terminal block. Other motors may be reversed by other methods which will be discussed later. Some motors may not be reversed.

Open - This indicates the conditions under which the motor can be operated. The "open" frame designation means that the motor should not be used in a wet or dusty environment.

Some of the nameplate information is not discussed here because it is for the manufacturer's use or it will be discussed later in this lesson.

4. Types and Uses of Common Electric Motors

There are six different types of common electric motors. The motor selected will depend upon how it is to be used. A discussion of the types and uses is given below:

Transparency No. 4

Split-Phase Motor - The characteristics are as follows:

1. This is used for loads that are easy to start.
2. This type has a high starting current requirement and will draw 6 to 8 times its normal running current when starting.
3. The sizes normally available are from 1/20 Hp to 1/3 Hp and may be obtained in 1/2 Hp and 3/4 Hp sizes.
4. It is considered a constant speed motor and is single voltage, except in the 1/2 Hp and 3/4 Hp sizes.
5. This is one of the least expensive motors and is of simple construction.
6. It has a starting winding, starting switch, and a running winding.
7. This type has many applications for easy starting loads. Examples are emery wheel, bench saw, washing machine, and seed cleaner.

Transparency No. 5

The wiring diagram for a single voltage, split-phase motor is illustrated in the above transparency. Note the starting switch is in the starting winding. The starting switch is closed when the motor is at rest. As the motor reaches about 80% of its running speed, the starting switch opens. This stops the flow of current through the starting winding.

One end of the starting and running windings are placed together for one lead and the other ends of both windings are placed together for the other lead.

To reverse the rotation of the shaft, the ends of the starting windings are changed with respect to the running winding leads.

Transparency No. 6

Each of the windings in a motor may be identified by the use of the continuity test lamp illustrated in this transparency. To provide students with practice in testing windings, they should make a continuity test lamp and power lead.

If the leads of the continuity test lamp are connected to the ends of different windings, the light will not burn when plugged into an outlet. The winding being tested must complete the circuit in order for the light to burn.

When power leads are connected to the ends of the running winding, the motor will hum. The shaft can be turned either direction by hand and the motor will run.

When power leads are connected to the ends of the starting winding, the motor will start and stop as the centrifugal mechanism closes and opens the starting switch.

Transparency No. 7

Capacitor-Start Motor - As the name indicates, this motor has a capacitor in the starting winding to give the motor more starting force. It is used for loads that are fairly difficult to start. Other aspects of this type are given below:

1. It has medium starting current requirement and will draw 3 to 6 times its normal running current when starting.
2. It is considered a constant speed motor.
3. The sizes normally available are from 1/8 to 10 Hp.
4. Capacitor-start motors are usually more expensive than split-phase motors.
5. They may be obtained as a single voltage or dual-voltage motor.

6. Single voltage motors have a starting winding and one running winding. Dual voltage motors have a starting winding and two running windings.
7. It has many applications for more difficult starting loads. Examples are air compressors, pumps, blowers, feed grinders, conveyors, and power tools.

Transparency No. 8

The wiring diagram for a capacitor-start, single voltage motor is illustrated here. Note the capacitor and starting switch in the starting winding.

The windings on a capacitor-start, dual voltage motor may be identified with the continuity test lamp as was discussed for the split-phase motor.

Transparency No. 9

The wiring diagrams for a capacitor-start, dual voltage motor, when operating on 120 volts, are shown in this transparency. The running windings are wired in parallel.

Transparency No. 10

The wiring diagrams for a capacitor-start, dual voltage motor, when operating on 240 volts, are illustrated here. The running windings are wired in series.

Transparency No. 11

Repulsion-Start Motor - This motor is used for starting heavy loads. The high starting torque is provided by a wound rotor and brushes. Other characteristics are as follows:

1. It has low starting current requirement and will draw 2 to 3 times its normal running current when starting.
2. It is considered a constant speed motor.
3. It is usually available as a dual voltage motor.
4. The sizes normally available are from 1/6 to 10 Hp.
5. It is a heavy duty motor and is more expensive than the split-phase or capacitor-start motor.
6. It has many applications for heavy starting loads. Examples are feed mixers, large blowers, silo unloaders, elevators, compressors, and deep-well pumps.

Transparency No. 12

The wiring diagrams for operating on 120 volts and 240 volts are illustrated in this transparency. For 120-volt operation, the windings are wired in parallel, while the windings on 240-volt are wired in series.

The direction of rotation of the motor shaft may be changed by moving the brush-ring holder position as illustrated.

Transparencies Nos. 13 and 13a

Universal Motor - This motor is a series motor and can be operated on A.C. or D.C. current, and is designed for intermittent use. It has a short life when compared to the life of the other motors studied. Other aspects of this type are given below:

1. Universal motors are usually small in size, but may be obtained in sizes from 1/150 to 2 Hp.
2. This is a variable speed motor, depending upon the load.
3. This motor has a high starting torque and requires a high starting current.
4. It is normally used for portable tools and portable appliances.

Shaded-Pole Motor - This is a small, single-phase motor that operates on A.C. current. It has a low starting torque and is low in efficiency. It is available in sizes from 1/20 to 1/6 Hp, and is simply constructed. It is used for very light loads such as small fans, blowers, and circulating pumps on evaporative water coolers. The design and windings of the universal and shaded-pole motors are shown in the following transparency.

Transparency No. 14

Three-Phase Motor - This motor is of simple construction and is operated only on three-phase A.C. current. Other factors relative to this type are as follows:

1. It has medium to high starting torque.
2. This motor may be obtained with the designation of low, normal, or high starting current requirement.
3. Its design provides for "self-starting" and includes no starting mechanism.
4. The three-phase motor is a constant speed motor.
5. It is available in sizes from 1/4 to several thousand Hp.
6. It is primarily used on large equipment.
7. The sizes 1 Hp and larger are lower in cost than single-phase motors.

Transparency No. 15

The above illustrations show the wiring diagrams of a three-phase motor. To reverse the direction of rotation, any of the motor leads may be interchanged.

5. Motor Drives

Machinery and equipment driven by electric motors are operated at different speeds. For the machine to operate efficiently, it must be driven at a specified speed; therefore, before selecting an electric motor and the drive, the operating speed of the machine should be determined.

In the selection of a drive, two factors are considered: (1) operating speed of equipment, and (2) size of drive. The operating speed of newly purchased equipment should be relatively simple to determine, since an operator's manual generally accompanies the equipment. A nameplate or some other source might provide this information for used equipment.

The size of drive for a machine is not as critical as the operating speed, but the drive should be large enough to pull the load efficiently. Drives may be classified into two general types, which are (1) direct and (2) speed-conversion (belts and pulleys).

DIRECT DRIVE

A direct drive is a motor connected directly to a machine. The machine operates at the same speed as the motor. There are four kinds of direct drives. These are (1) flexible shaft, (2) flexible hose (3) cushion-flange coupling, and (4) flange coupling.

Transparency No. 16

Flexible Shaft Drive - This type is particularly useful for equipment that is operated at various angles. Grinders and buffers are examples. Since flexible shafts are manufactured to operate in only one direction, the direction the shaft is to be operated (clockwise or counter clockwise) should be specified when a shaft is purchased. The machine with this type is operated at the same speed as is the motor.

Flexible Hose Coupling Drive - A piece of plastic or rubber hose can be used as the drive. The ends of the hose are forced over the ends of the machine and motor shaft and are held in place with clamps.

Cushion-Flange Coupling Drive - This type consists of two flanges, which are attached to the shafts, and a flexible center part, which is fastened to the flanges. A flexible action is furnished by the center part which is made of rubber or a similar material.

Flange Coupling Drive - Two metal discs and a flexible middle disc are components of this type. The metal discs are fastened to the motor and

machine shafts, and the middle disc is placed between the metal discs. The parts are then fastened together.

SPEED-CONVERSION DRIVES

Transparency No. 17

These are used to drive equipment and machines at a speed which is different from that of the motor furnishing the power. The three types of speed conversion drives are (1) pulley-and-belt, (2) gear, and (3) chain-and-sprocket.

Since the gear and chain-and-sprocket drives are generally included as a part of the machine to be driven and are very complex, and since the pulley-and-belt drive is most often used on the farm, it is the only one discussed.

PULLEY-AND-BELT DRIVE

The pulley is a very important part of the driven system. Generally, the larger the pulley the better, because less slippage occurs when more pulley area is in contact with the belt.

To prevent slippage, a pulley at least two inches in diameter should be used on motors of 1/2 Hp or less. If belt slippage will not affect the operation of equipment, a smaller diameter pulley may be used. For motors larger than 1/2 Hp, a three-inch diameter pulley is recommended.

A jack shaft (shaft with a pulley on both ends) is recommended as a part of the drive for equipment designed to operate on less than 200 rpm. It is recommended that the pulley connecting the jack shaft to the motor be 12 inches in diameter.

The four types of pulley-and-belt drives are (1) V-flat, (2) webbed multi-V belt, (3) flat-belt, and (4) V-flat drive. A discussion of each type follows:

V-Belt Drive - This is the most popular drive used with electric motors. It has several advantages: The motor may be mounted on or close to the machine, and less tension is needed on the belt because of the wedging action of the belt and the pulley groove. Also, the belt stays on the pulley better.

Transparency No. 18

Three sizes of V-belts are normally used on farms. These are the fractional-horsepower (FHP), A-section, and B-section.

The FHP is suited for pulleys 2 1/2 inches and less in diameter. They are thinner and much more flexible.

The A-section V-belt is heavier and can be used on small pulleys, but there is more slippage than the thinner belt. The stiffness of the belt prevents it from following the curvature of the pulleys. It is designed for pulleys three inches in diameter or larger.

B-section V-belts are designed for use on motors of 3 Hp or larger. The motor pulley should be 5 1/2 inches or larger in diameter.

Number and Types of V-Belts Recommended for 1750 RPM Motors

Diameter of Motor Pulley in Inches	Size of Motor							
	Horsepower							
	½ or Smaller	3/4	1	1½	2	3	5	7½
2	FHP*	FHP*						
3	1-A	1-A	1-A	2-A	2-A	3-A	5-A	8-A
4	1-A	1-A	1-A	1-A	2-A	2-A	3-A	5-A
5	1-A	1-A	1-A	1-A	1-A	2-A	3-A	4-A
6	1-A	1-A	1-A	1-A	1-A	1-B	2-B	2-B
7	1-A	1-A	1-A	1-A	1-A	1-B	2-B**	2-B
8	1-A	1-A	1-A	1-A	1-A	1-B**	1-B	2-B

*FHP- (Fractional Horsepower) a belt designed for small pulleys and small motors. Most commonly available in 3/8 inch width but also available in 1/2 and 5/8 widths.
**The same number of Type A belts could be used instead of Type B. On multiple belt drives, all belts should be replaced at one time.

Many of the farm motors are fractional-horsepower and require only a single V-belt to drive the machine. Three types of V-pulleys are available. These are the standard V-, V-step-, and adjustable V-pulleys. The standard V-pulley is used when only one speed is needed, while the V-step pulley is used for machine driven variable speeds, such as would be used on a drillpress. The adjustable V-pulley is also for variable speeds. The diameter of the pulley may be increased or decreased to adjust the speed to the desired rpm.

To determine the length of a V-belt for a mounted motor, a piece of string is looped around and in the grooves of the pulleys, pulled tight, and a knot tied in ends of the string. The string is cut, and its length is measured. This gives the inside length of the belt needed.

The following procedure may be used to determine the size of belt to use for an unmounted motor:

4 x diameter of largest pulley _____
1.6 x diameter of motor pulley _____
1.6 x diameter of machine pulley _____
Total length _____

Example: Motor pulley 3 inches, machine pulley 6 inches

4 x 6 = 24.0 inches
1.6 x 3 = 4.8 inches
1.6 x 6 = 9.6 inches
Total 38.4

The closest standard length belt to the above measurement should be purchased, and the motor should be mounted at a distance from the machine shaft to provide adequate tension on the belt.

Webbed Multi-V-Belt - Two or more V-belts webbed together make up this type. Its main advantages are the elimination of slippage and belt turnover.

Flat-Belt - The flat drive consists of a flat pulley on the motor, as well as one on the machine being driven. This is used for motors located some distance from the machine. A feed grinder is an example. A pressed-paper pulley should be used for high speeds, while steel, wood, or cast iron pulleys may be used for slow speeds. The most popular flat belts for farm use are made of rubber.

V-Flat Belt Drive - This type consists of one or more V-belts, one V-pulley, and one flat pulley. This system is recommended for machines with pulleys larger than 12 inches in diameter and operated at 600 rpm or less. The distance from the center of the motor pulley to the center of the machine pulley should not be greater than the diameter of the equipment pulley. Following this recommendation will prevent belt slippage.

Determining the Proper Size Pulley to Use - The following formula is used to determine the proper pulley size for an inline motor and machine:

(rpm of motor) x (Diameter of motor pulley) = (rpm of machine) x (Diameter of machine pulley).

In the following example, the size of pulley needed to turn a fan at 875 rpm is determined. The fan is driven by 1/3 Hp electric motor which operates at 1750 rpm and has a pulley two inches in diameter.

Step No. 1 - 1750 x 2 = 875 x Dia. Machine Pulley

Step No. 2 - $D = \frac{1750 \times 2}{875} = 4$ inches - pulley diameter needed on machine

The following is the procedure to use to determine the diameter of pulleys needed on motor, jack shaft, and machine when this drive system is used.

In the following example, it is assumed that the machine should operate at 60 rpm and the motor speed is 1750 rpm.

Previous recommendations were that a two-inch pulley be used on fractional-horsepower motors and that the jack shaft have one pulley 12 inches in diameter.

Step No. 1 - Calculate speed of jack shaft. The following formula is used:

rpm (motor) x D (motor pulley) = rpm (jack shaft) x D (jack shaft pulley)

1750 x 2 = rpm (jack shaft) x 12

$\text{rpm (jack shaft)} = \frac{1750 \times 2}{12} = 292 \text{ rpm}$

Step No. 2 - Determine size of pulley for machine

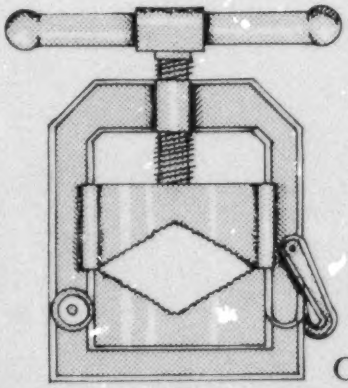
292 rpm x diameter (other jack shaft pulley) = 60 rpm x D (machine).

A two-inch pulley is tried for the other jack shaft pulley 292 rpm x 2 in. = 60 rpm x D (machine pulley) Diameter of machine pulley = $\frac{292 \times 2}{60}$ = 9.8 or 10 inch pulley is needed for machine.

References:

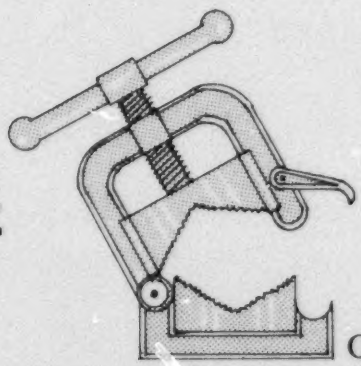
1. Texas Education Agency, "Electric Motors Lesson Plans for Production Agriculture", Vocational Instructional Services, Texas A&M University, College Station, Texas, 1979.

PLUMBING TOOLS

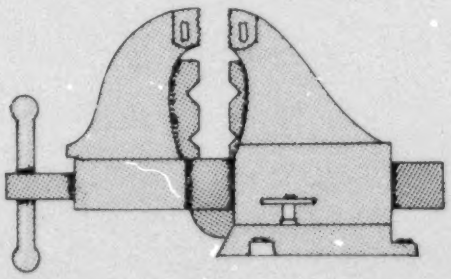


CLOSED

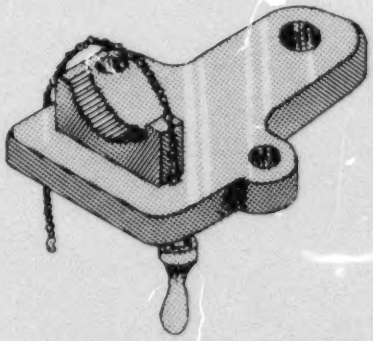
HINGED PIPE VISE



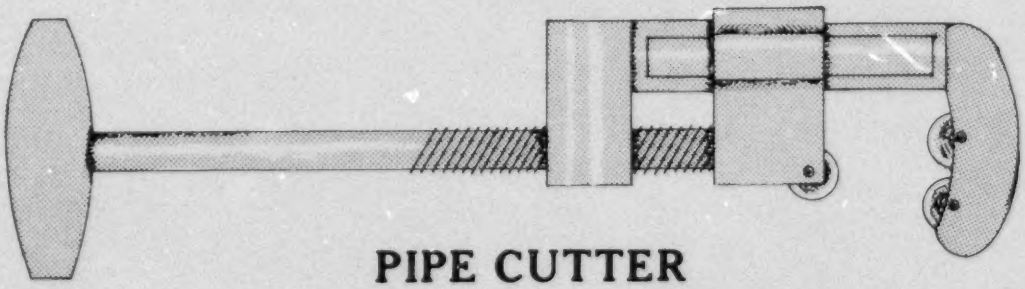
OPEN



COMBINATION PIPE VISE



CHAIN PIPE VISE



PIPE CUTTER

ADVANTAGES OF ELECTRIC MOTORS

1. INEXPENSIVE TO OPERATE
2. ALWAYS READY TO WORK
3. HIGHLY EFFICIENT
4. LONG LIFE
5. SIMPLE TO OPERATE
6. SAFE
7. MINIMUM SERVICING
8. QUIET OPERATION
9. COMPACT AND AUTOMATIC – ALLY CONTROLLED
10. ADAPTABLE

FACTORS IN SELECTING ELECTRIC MOTORS

TYPE OF POWER AVAILABLE

SIZE OF MOTOR (HORSEPOWER)

STARTING LOAD REQUIREMENT

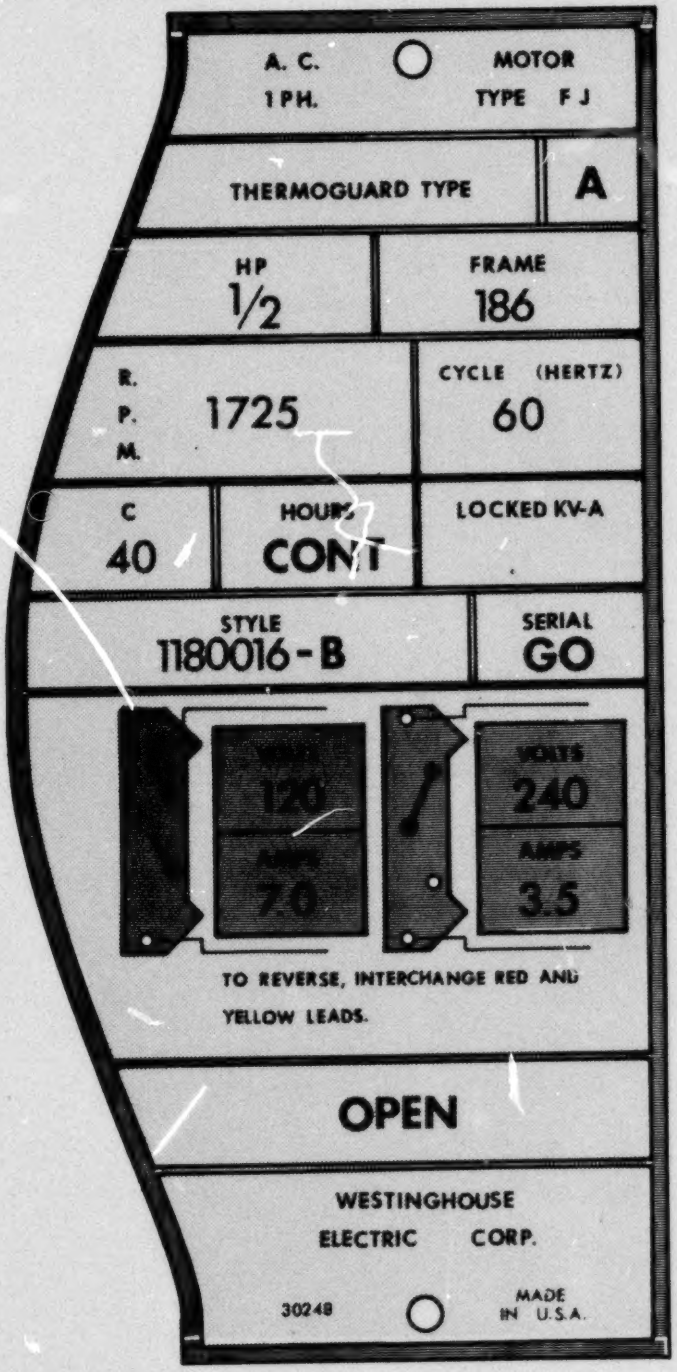
SPEED REQUIREMENT

TYPE OF BEARINGS

TYPE OF BASE OR MOUNT

ENVIRONMENT

MOTOR NAME PLATE



SPLIT-PHASE MOTOR

FOR EASY STARTING LOADS

HIGH STARTING CURRENT—
6-8 TIMES FULL LOAD CURRENT

SIZES AVAILABLE—
1/20 HP TO 3/4 HP

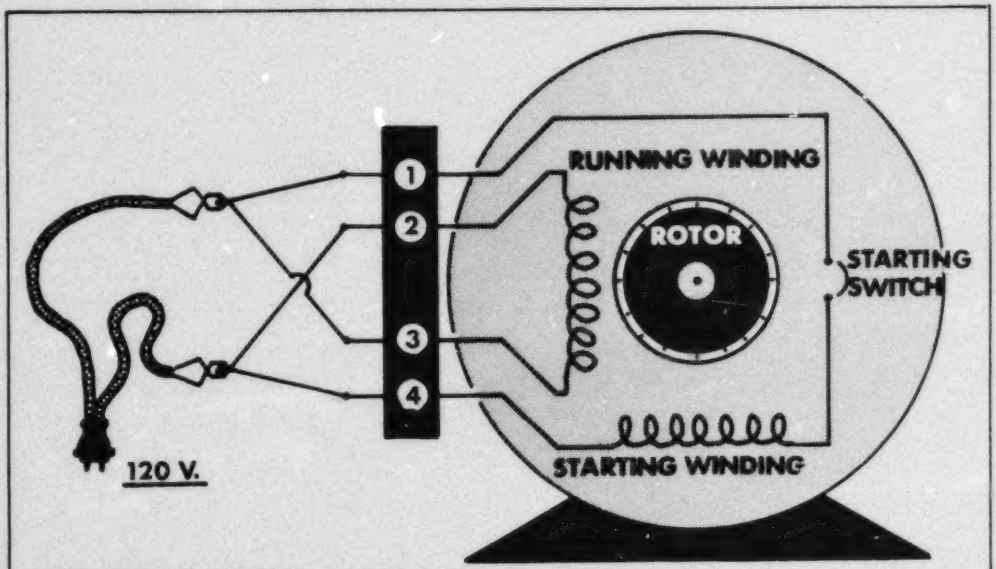
CONSTANT SPEED—
SINGLE VOLTAGE

INEXPENSIVE—
SIMPLE CONSTRUCTION

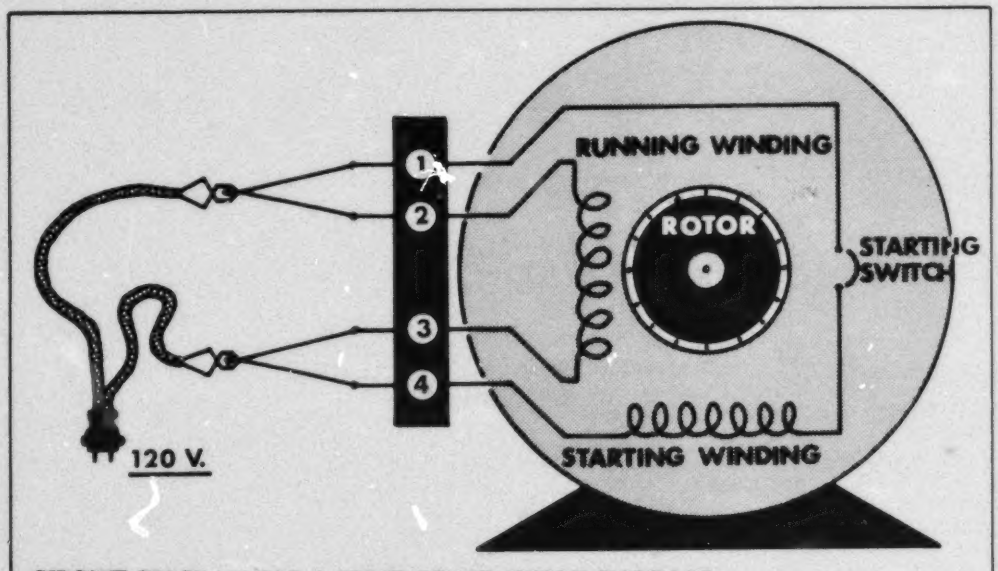
HAS STARTING WINDING &
STARTING SWITCH

APPLICATIONS--
EMERY WHEEL - SEED CLEANER
BENCH SAW-WASHING MACHINE

SPLIT-PHASE

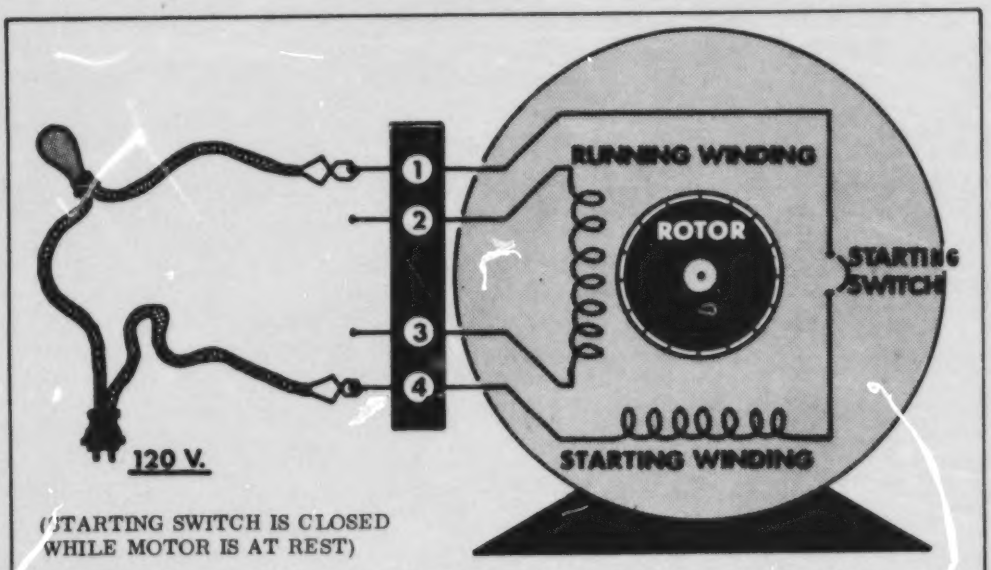


CIRCUIT DIAGRAM FOR A SPLIT-PHASE SINGLE-VOLTAGE MOTOR OPERATING IN ONE DIRECTION.



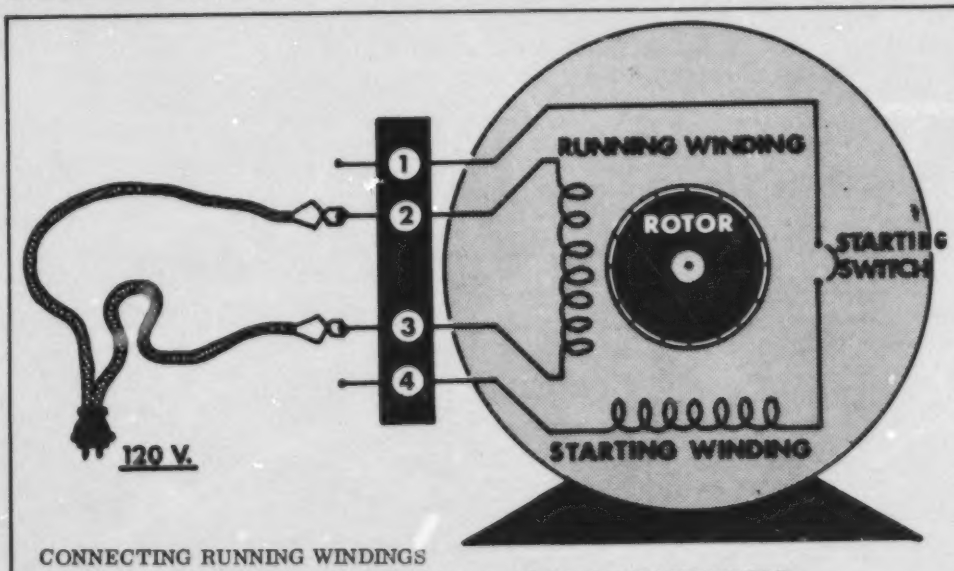
CIRCUIT DIAGRAM FOR A SPLIT-PHASE SINGLE-VOLTAGE MOTOR OPERATING IN OPPOSITE DIRECTION.

TESTING WINDINGS



(STARTING SWITCH IS CLOSED WHILE MOTOR IS AT REST)

TESTING STARTING AND RUNNING WINDINGS ON A SPLIT-PHASE SINGLE-VOLTAGE MOTOR. TEST STARTING WINDING AS SHOWN. TEST RUNNING WINDING BY ATTACHING TEST LEADS TO #2 AND #3.



CONNECTING RUNNING WINDINGS TO POWER LEADS ON A SPLIT-PHASE SINGLE-VOLTAGE MOTOR.

CAPACITOR START-INDUCTION RUN MOTOR

HAS A CAPACITOR IN THE STARTING WINDING

USED FOR DIFFICULT STARTING LOADS

MEDIUM STARTING CURRENT – 3-6 TIMES FULL LOAD CURRENT

CONSTANT SPEED – 900-3600 rpm.

SIZES – 1/8 HP TO 10 HP

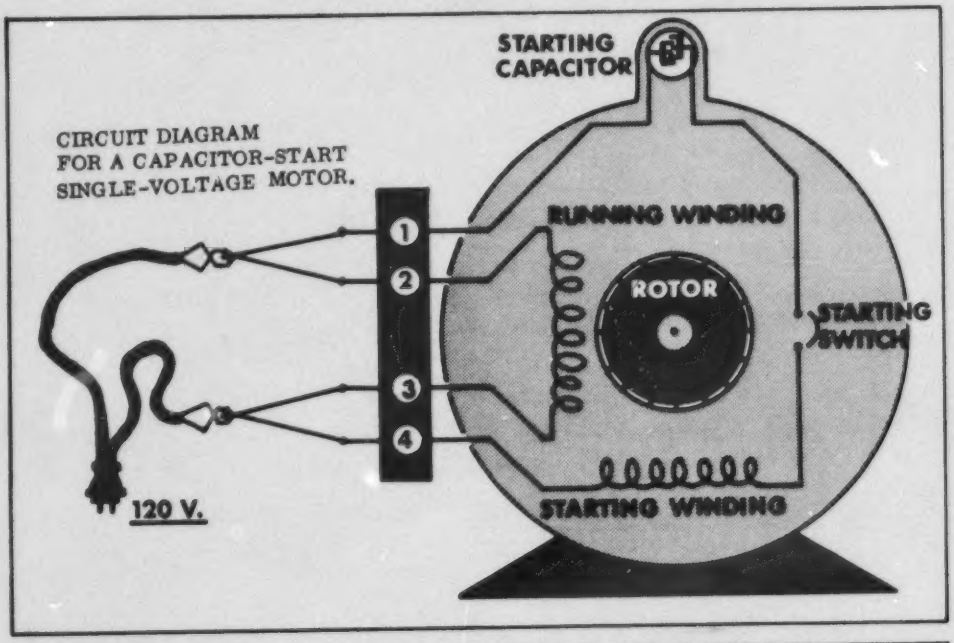
25-40% MORE EXPENSIVE THAN SPLIT-PHASE MOTORS

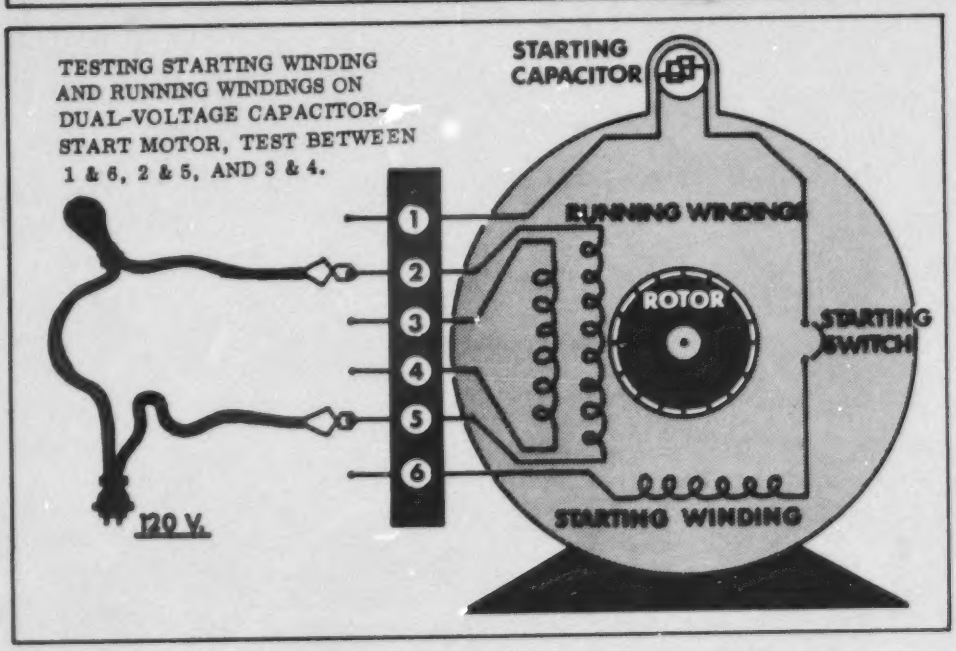
SINGLE OR DUAL VOLTAGE – 120/240 VOLTS

HEAVY DUTY APPLICATIONS --

AIR COMPRESSORS	PUMPS
FEED GRINDERS	BLOWERS
POWER TOOLS	CONVEYORS

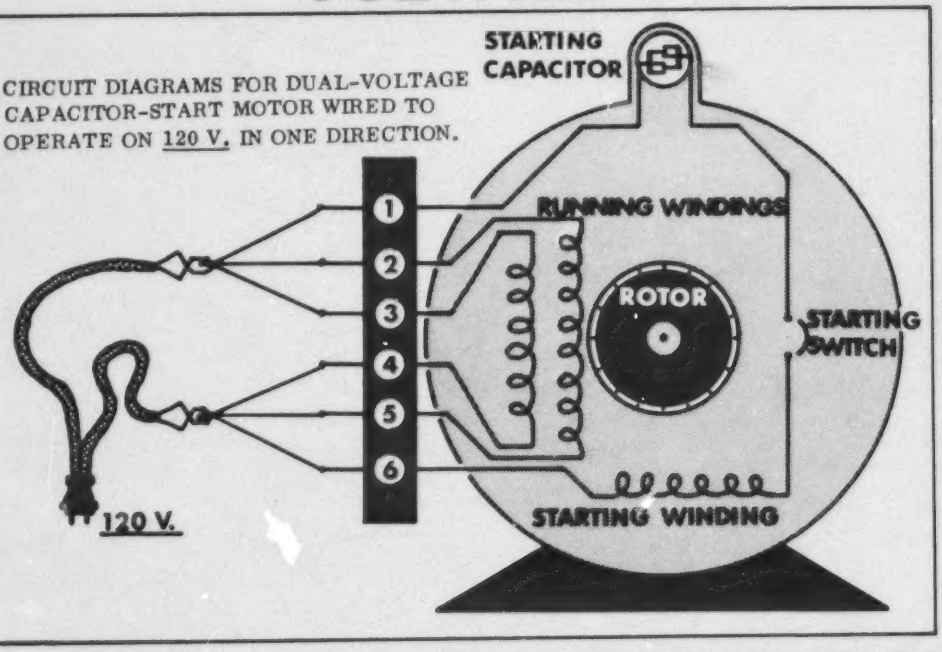
CAPACITOR-START



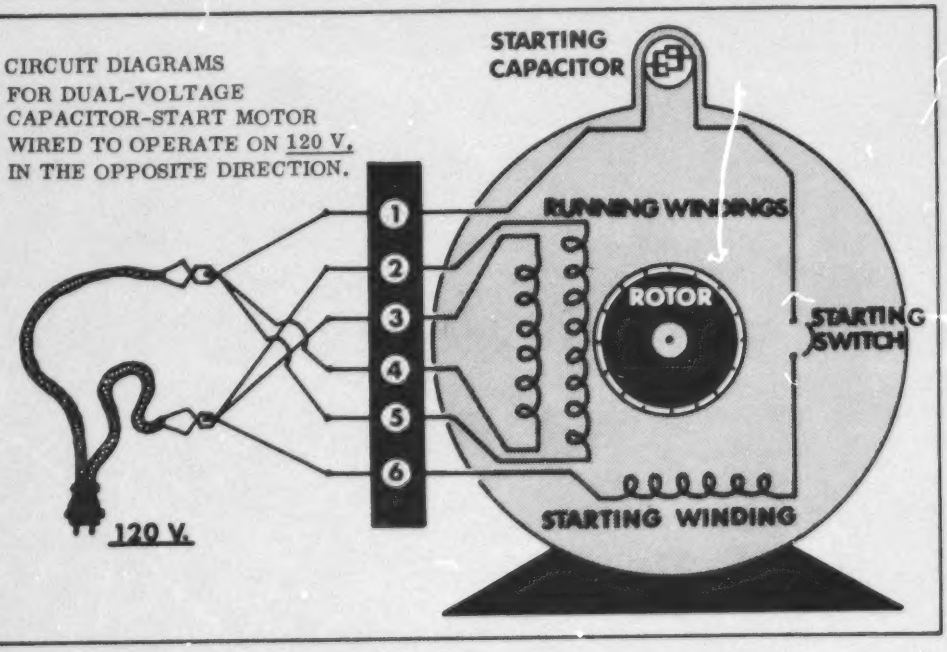


CAPACITOR-START DUAL VOLTAGE

CIRCUIT DIAGRAMS FOR DUAL-VOLTAGE CAPACITOR-START MOTOR WIRED TO OPERATE ON 120 V. IN ONE DIRECTION.

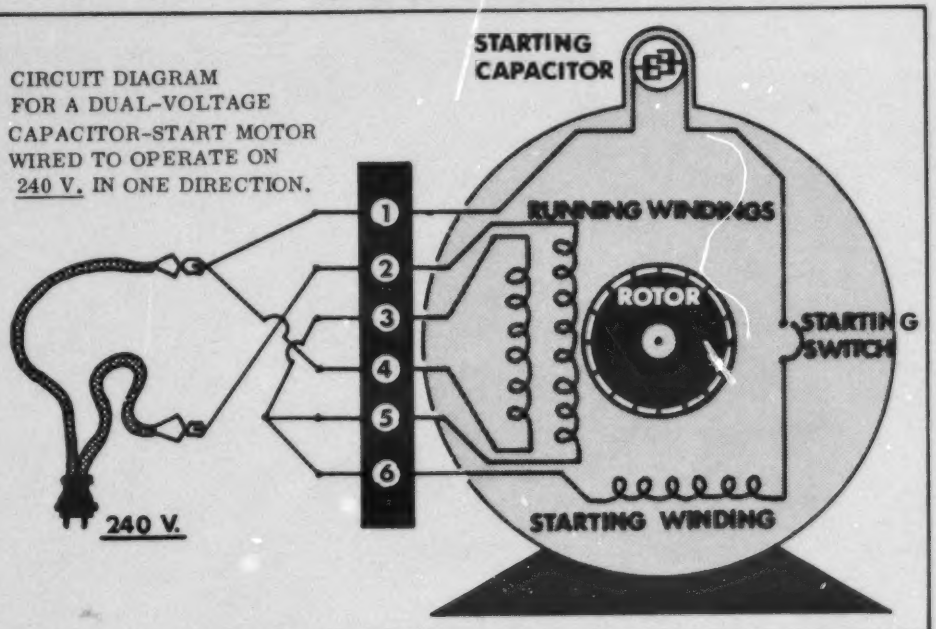


CIRCUIT DIAGRAMS FOR DUAL-VOLTAGE CAPACITOR-START MOTOR WIRED TO OPERATE ON 120 V. IN THE OPPOSITE DIRECTION.

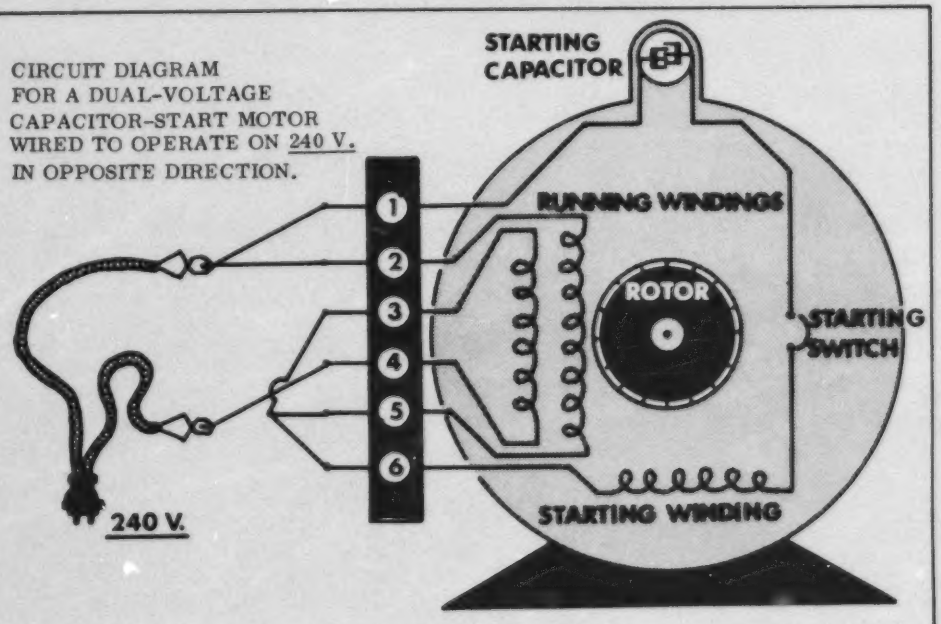


CAPACITOR-START DUAL VOLTAGE

CIRCUIT DIAGRAM
FOR A DUAL-VOLTAGE
CAPACITOR-START MOTOR
WIRED TO OPERATE ON
240 V. IN ONE DIRECTION.



CIRCUIT DIAGRAM
FOR A DUAL-VOLTAGE
CAPACITOR-START MOTOR
WIRED TO OPERATE ON 240 V.
IN OPPOSITE DIRECTION.



REPULSION-START MOTOR

USED FOR HEAVY STARTING LOADS

USES WOUND ROTOR AND BRUSHES FOR STARTING

HIGH STARTING TORQUE- LOW STARTING CURRENT- 2-4 TIMES FULL LOAD CURRENT

CONSTANT SPEED – 1200 or 1800 rpm.

USUALLY DUAL VOLTAGE- 120/240 VOLTS

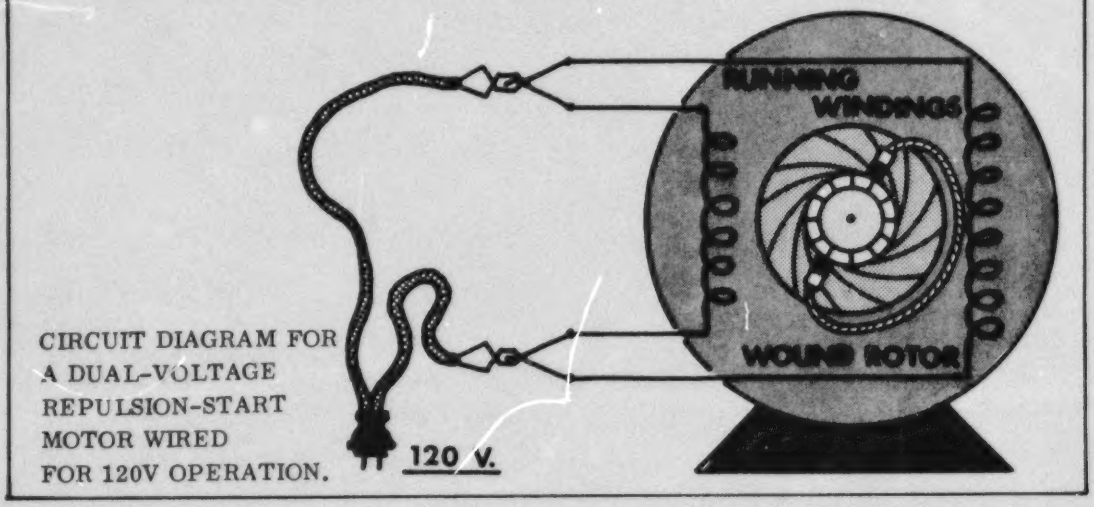
SIZES–1/6 HP TO 10 HP

HEAVY DUTY–MORE EXPENSIVE TYPE MOTOR

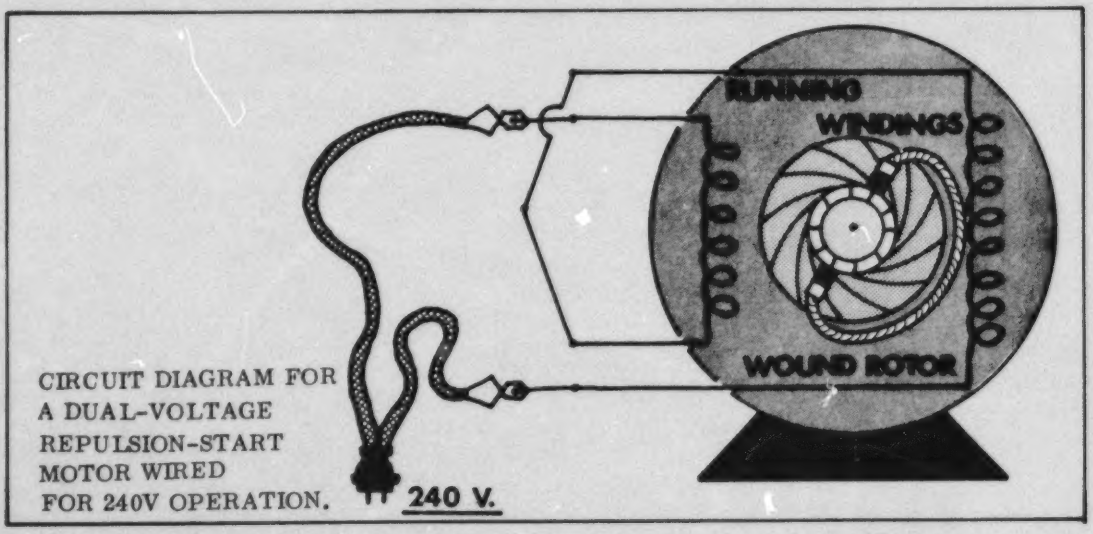
APPLICATIONS--

LARGE BLOWERS	COMPRESSORS
SILO UNLOADERS	FEED MILLS
DEEP WELL PUMPS	ELEVATORS

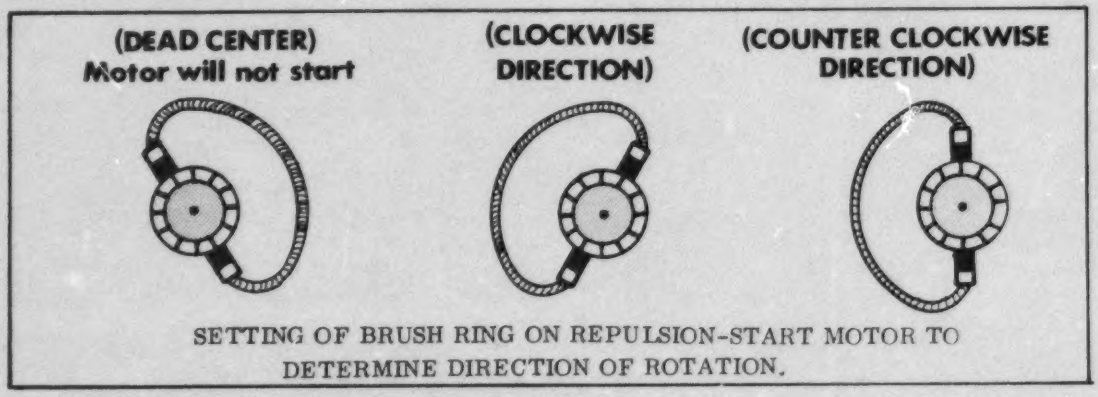
REPULSION-START



CIRCUIT DIAGRAM FOR A DUAL-VOLTAGE REPULSION-START MOTOR WIRED FOR 120V OPERATION.



CIRCUIT DIAGRAM FOR A DUAL-VOLTAGE REPULSION-START MOTOR WIRED FOR 240V OPERATION.



SETTING OF BRUSH RING ON REPULSION-START MOTOR TO DETERMINE DIRECTION OF ROTATION.

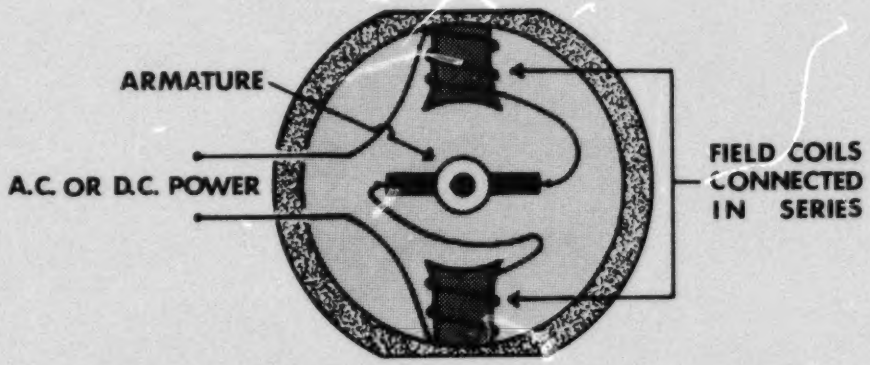
UNIVERSAL MOTOR

1. OPERATES ON AC OR DC
2. SHORT LIFE–INTERMITTENT USE
3. 1/150 TO 2 HORSEPOWER
4. SPEED DEPENDS UPON LOAD
5. HIGH STARTING TORQUE–HIGH STARTING CURRENT
6. USED FOR PORTABLE TOOLS AND APPLIANCES

SHADED-POLE MOTOR

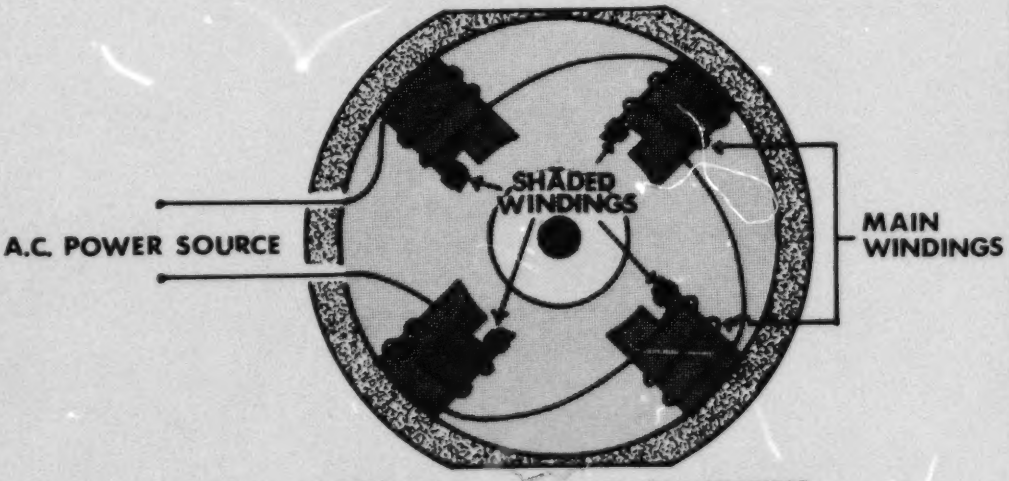
1. SMALL SINGLE-PHASE AC MOTOR
2. LOW STARTING TORQUE–LOW EFFICIENCY
3. 1/20 TO 1/6 HORSEPOWER
4. SIMPLE CONSTRUCTION–FOR LIGHT DUTY SUCH AS SMALL FANS, BLOWERS, ETC.

UNIVERSAL MOTOR



SERIES CONNECTION OF A UNIVERSAL MOTOR

SHADED-POLE MOTOR

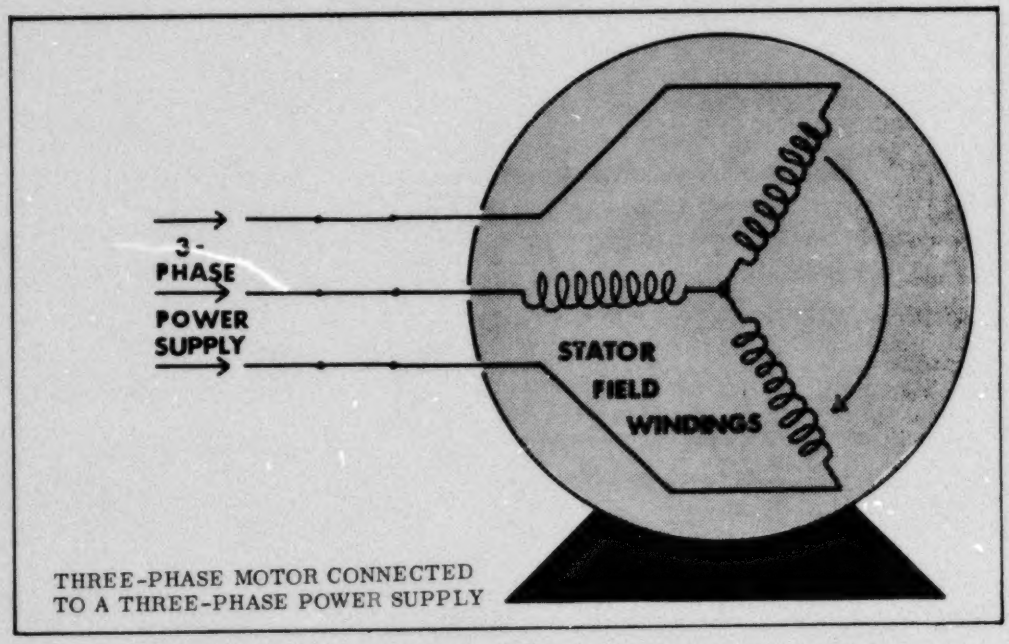


FOUR - POLE, SHADED - POLE MOTOR SHOWING
MAIN WINDINGS AND SHADED WINDINGS

THREE-PHASE MOTOR

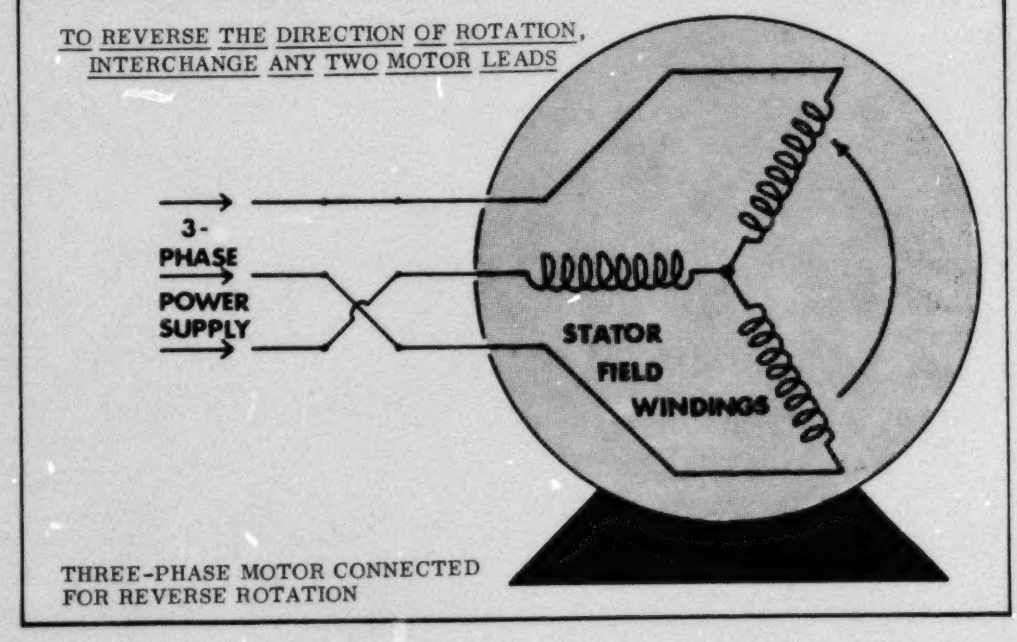
1. SIMPLE CONSTRUCTION
2. USED ON THREE-PHASE ALTERNATING CURRENT POWER SOURCE ONLY
3. MEDIUM TO HIGH STARTING TORQUE
4. LOW, NORMAL AND HIGH STARTING CURRENT
5. "SELF-STARTING"—NO STARTING MECHANISM REQUIRED
6. CONSTANT SPEED MOTOR
7. SIZES—1/4 HP TO SEVERAL THOUSAND HP
8. USED PRIMARILY ON LARGE EQUIPMENT
9. SIZES 1 HP AND LARGER ARE LOWER IN COST THAN SINGLE-PHASE MOTORS

THREE PHASE



THREE-PHASE MOTOR CONNECTED
TO A THREE-PHASE POWER SUPPLY

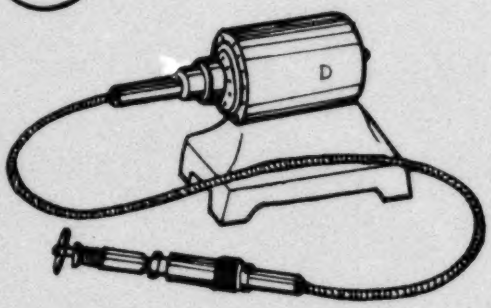
TO REVERSE THE DIRECTION OF ROTATION,
INTERCHANGE ANY TWO MOTOR LEADS



THREE-PHASE MOTOR CONNECTED
FOR REVERSE ROTATION

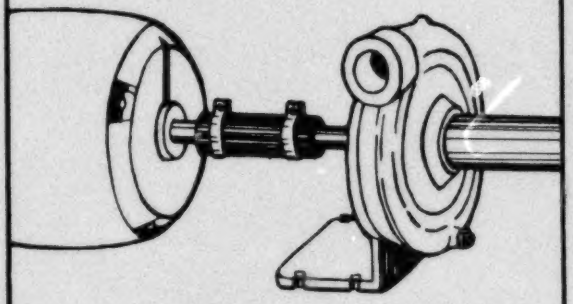
DIRECT DRIVES

1



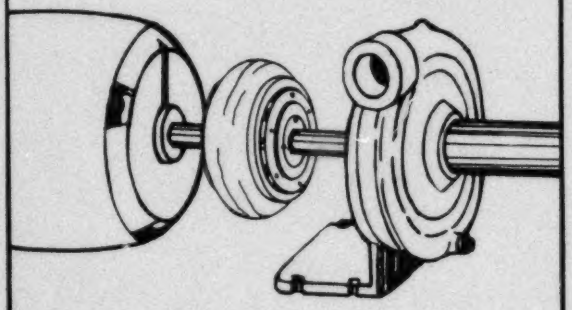
FLEXIBLE SHAFT

2



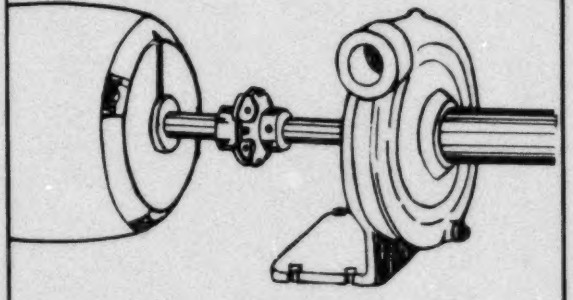
FLEXIBLE HOSE COUPLING

3



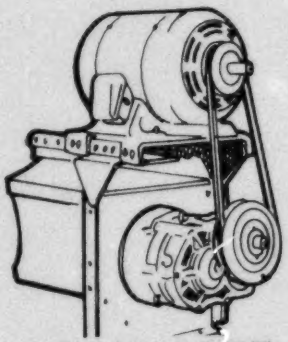
CUSHION-FLANGE COUPLING

4

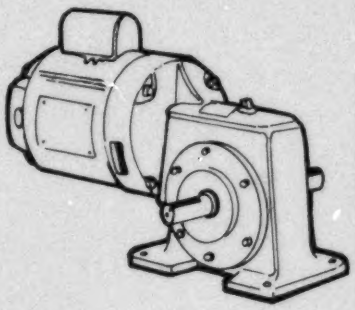


FLANGE COUPLING

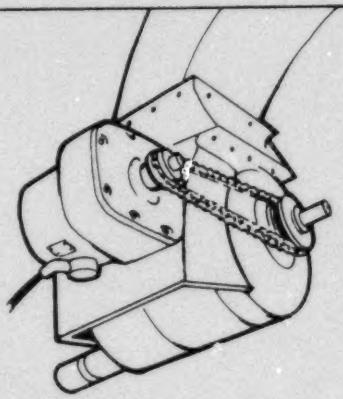
SPEED-CONVERSION DRIVES



PULLEY & BELT

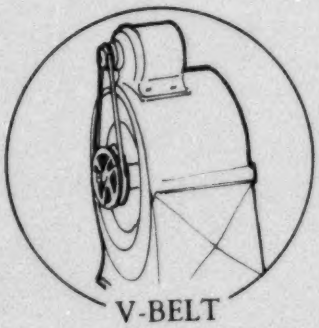


GEAR

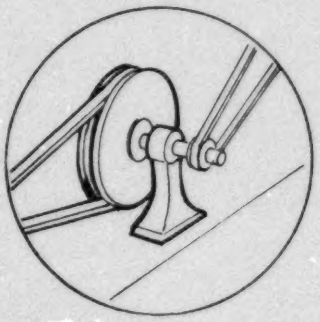


CHAIN & SPROCKET

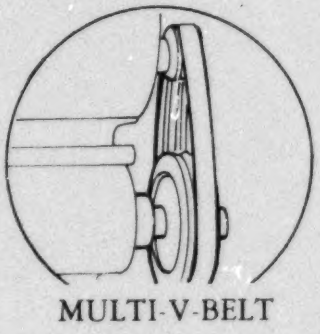
PULLEY & BELT DRIVES



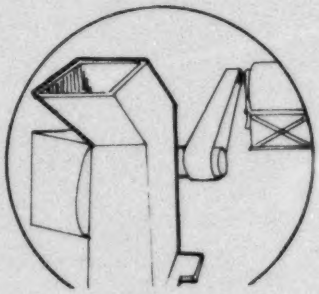
V-BELT



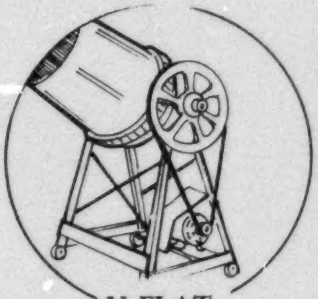
JACK SHAFT



MULTI-V-BELT

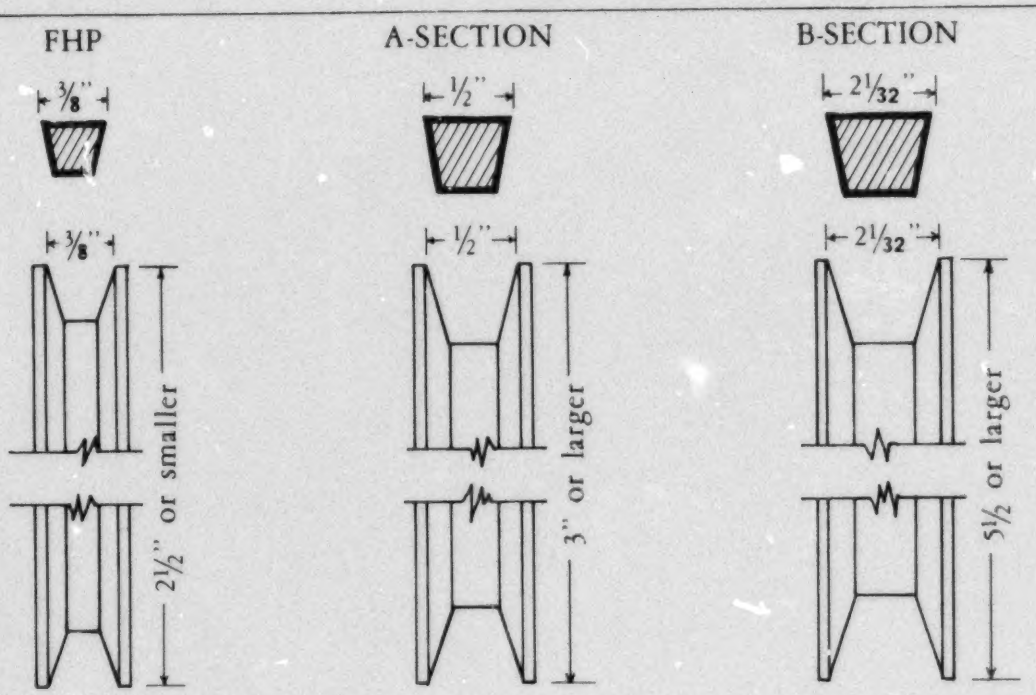


FLAT-BELT

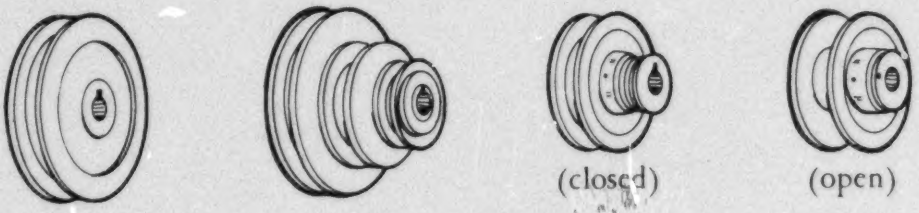


V-FLAT

COMMON V-BELTS & PULLEYS



V-PULLEYS



STANDARD V-STEP ADJUSTABLE

CONSTRUCTION AND MAINTENANCE

Unit D: Farm Electricity

Topic 4: Care and Maintenance of Electric Motors

Suggested Procedure and Activities: During the discussion and explanation of the information, the transparencies may be utilized and the teacher may demonstrate how to disassemble, clean, and reassemble a motor.

1. Motor Protection and Maintenance

Transparency No. 1

Overload Protection

An electric motor should be protected from performing more work than it is designed to perform. If the motor is overloaded, the ampere flow is likely to become great enough to damage the motor.

Overload can be caused by (1) motor size too small for the job, (2) improper wiring and low voltage, (3) improper installation, (4) belts too tight, (5) improper lubrication, or (6) the entry of foreign materials (dust, water, or oil) into the motor.

Overload protection may be provided by (1) proper fusing of the motor circuit, (2) built in protection in the motor, (3) manual reset switch control, or (4) special motor starter (current-limiting starter).

Transparencies Nos. 2a and 2b

Proper Installation

The installation of an electric motor should be made so that a minimum of vibration will occur. It is also very important to make the installation so that proper alignment will result. Misalignment will cause wear and may also be factor in overloading a motor.

Transparency No. 3

Prevent Friction

A minimum of friction in the mechanical operation of a motor is necessary to prevent excessive wear and possible overloading of the motor.

The manufacturer's recommendations for lubrication intervals should be closely followed.

A high-quality lubricant should be used for motor lubrication.

Motors with sleeve bearings require mounting so that the shaft is horizontal and level for proper lubrication.

Worn bearings should be replaced and the alignment of motor, drive, and equipment should be true.

Transparency No. 4

Protect From Dust

The accumulation of dust in and on a motor acts as insulation and may cause excessive heating of the motor.

Dust and other foreign materials counteract lubrication and will cause friction and wear in the bearings and shaft.

The dust should be wiped from motors at regular intervals. Air under pressure (not more than 40 pounds per square inch pressure) should be used to blow dust from the windings at regular intervals. Excessive lubrication should be avoided to prevent excessive accumulation of dust. Dust seals and oil caps on motors should be in good condition and kept closed.

Transparency No. 5

Protect From Moisture

Moisture is a conductor of electricity. Dry insulation confines the current to the correct path. When insulation is wet, the current may not be properly confined and a "short" may result.

Motors may be protected from moisture by well-ventilated enclosures.

A wet motor should be dried thoroughly before it is used. Some type of heat and a fan may be applied to the motor to dry it thoroughly.

Transparency No. 6

Protect From Excessive Oil

Too much oil or grease can be harmful to an electric motor. Damage from too much oil may result from the accumulation of extra dust or from the

deterioration of insulation within the motor.

The manufacturer's recommendations for lubricating a motor should be closely followed.

To remove excessive oil, a non-inflammable solvent and a paint brush may be used.

2. Checking and Cleaning Electric Motors

Disassembly of Split-Phase Motor

(a) Mark the end plates and frame with a center punch or other marking device to insure the proper reassembly of the motor.
(b) Remove the through bolts or screws and remove the end plate. (A light tap may be needed to loosen the end plate.)
(c) Remove the rotor (center shaft).
(d) Notice the wiring connections on the terminal wiring plate and the starting switch.
(e) Identify the following parts:

Transparency No. 7

1. Motor base
2. End plates
3. Bearings
4. Rotor
5. Fan
6. Centrifugal mechanism
7. Starting switch
8. Oil or grease rings
9. Stator windings
10. Protective device

Cleaning and Checking Split-Phase Motor

(a) Clean motor and motor parts, using a non-inflammable cleaning solvent and paint brush.
(b) Disconnect the wiring leads from the terminal wiring plate. Use a continuity test lamp to determine which two leads complete a circuit in the stator windings. Two separate windings should be identified - a running winding and a starting winding. (The running winding will be a heavier wire than the starting winding wire.)
(c) Check each winding for a "short" by connecting one lead of the continuity test lamp to one end of a winding. With the continuity test lamp energized, touch the other lead of the lamp to the motor frame. If the light burns, it indicates a "short" between the winding and the metal frame. Test the other winding in the same manner. If a short is indicated, the motor should be rewound or replaced.

Reassembly of Split-Phase Motor

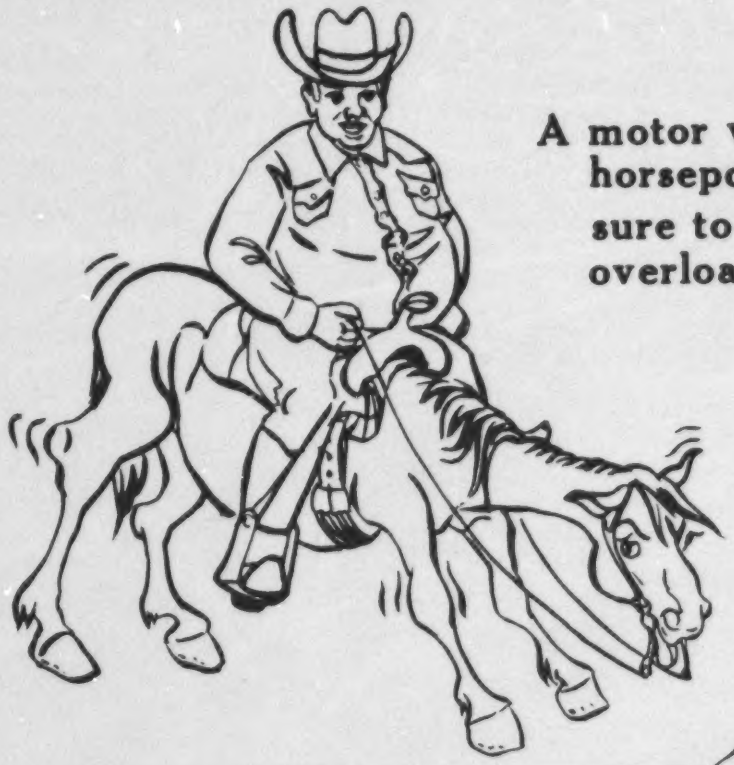
(a) Connect wiring leads to the proper terminals on the terminal wiring plate.
(b) Replace rotor.
(c) Replace end plate, being careful to replace it in its original position. (The center punch marks were made for this purpose.)
(d) Replace through bolts and tighten evenly. Determine that the rotor turns freely after the through bolts have been tightened.
(e) Energize the motor and check its operation.

References:

1. Texas Education Agency, "Electric Motors Lesson Plans for Production Agriculture", Vocational Instructional Services, Texas A&M University, College Station, Texas, 1979.

2. "Electric Motors - Selection, Protection, and Drives," American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1978.

OVERLOAD



A motor worked beyond its horsepower capacity is sure to breakdown as an overloaded horse will

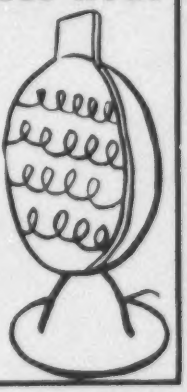
HEAT DAMAGE

Heat melts

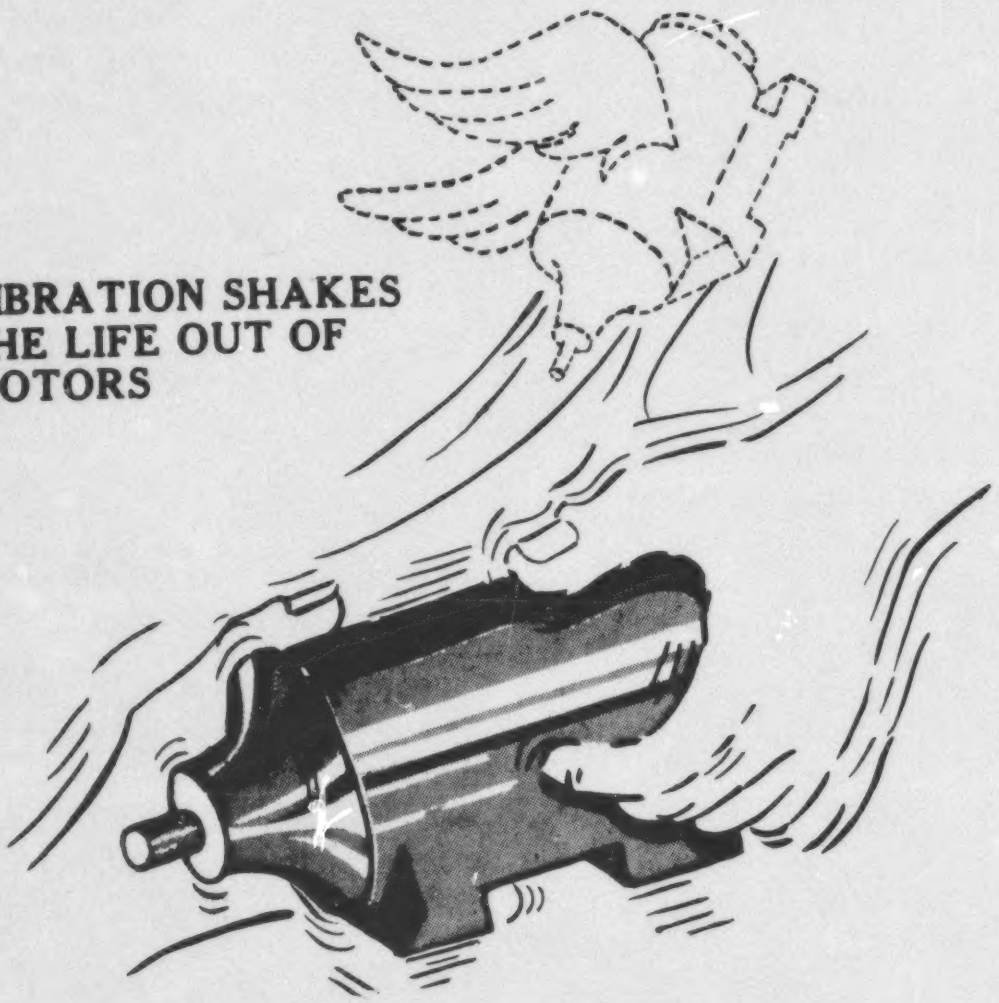
Heat "fries" insulation

Friction makes heat

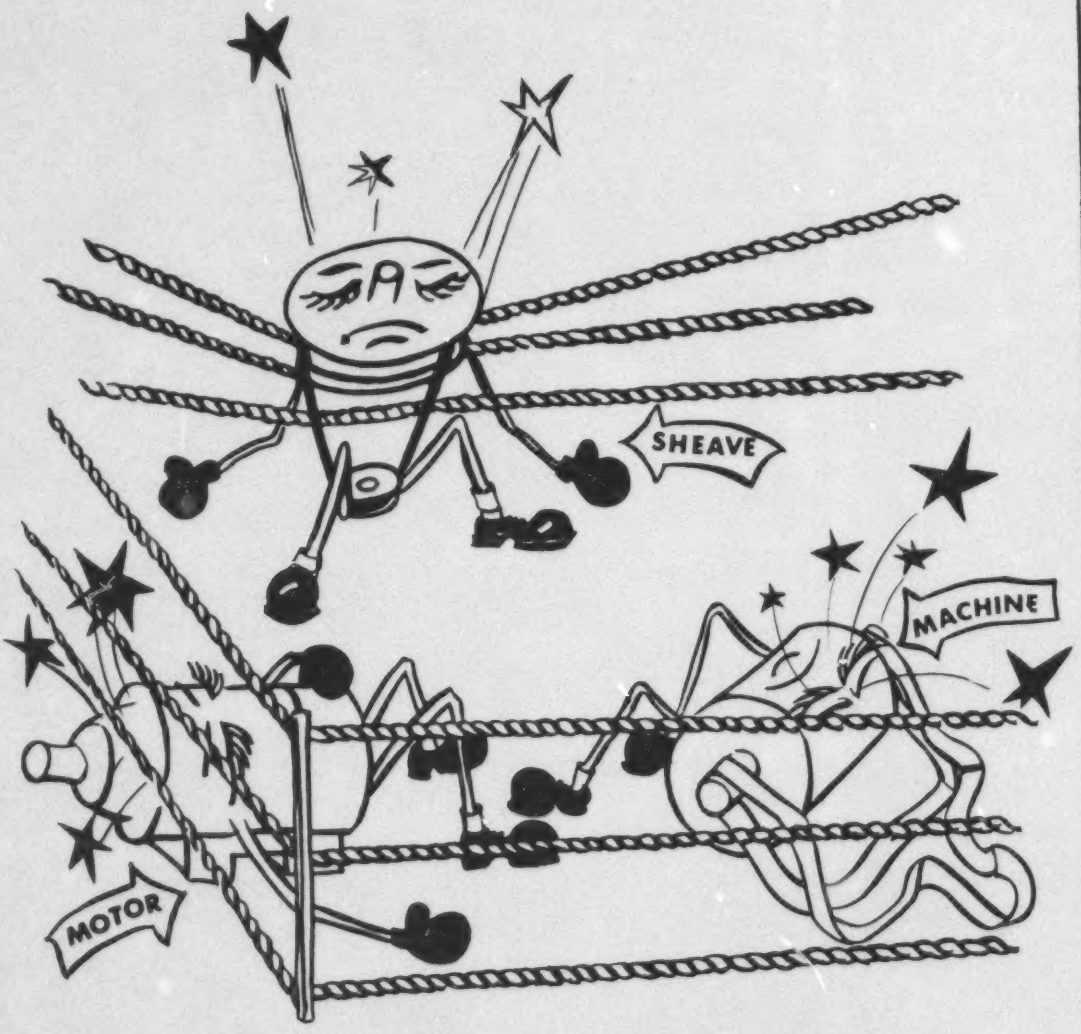
Electrical resistance makes heat



VIBRATION

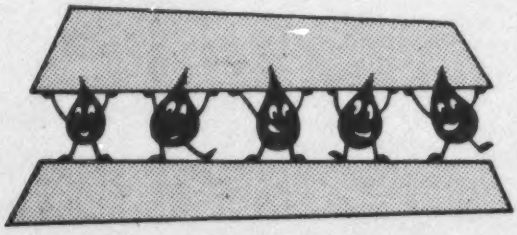


MISALIGNMENT

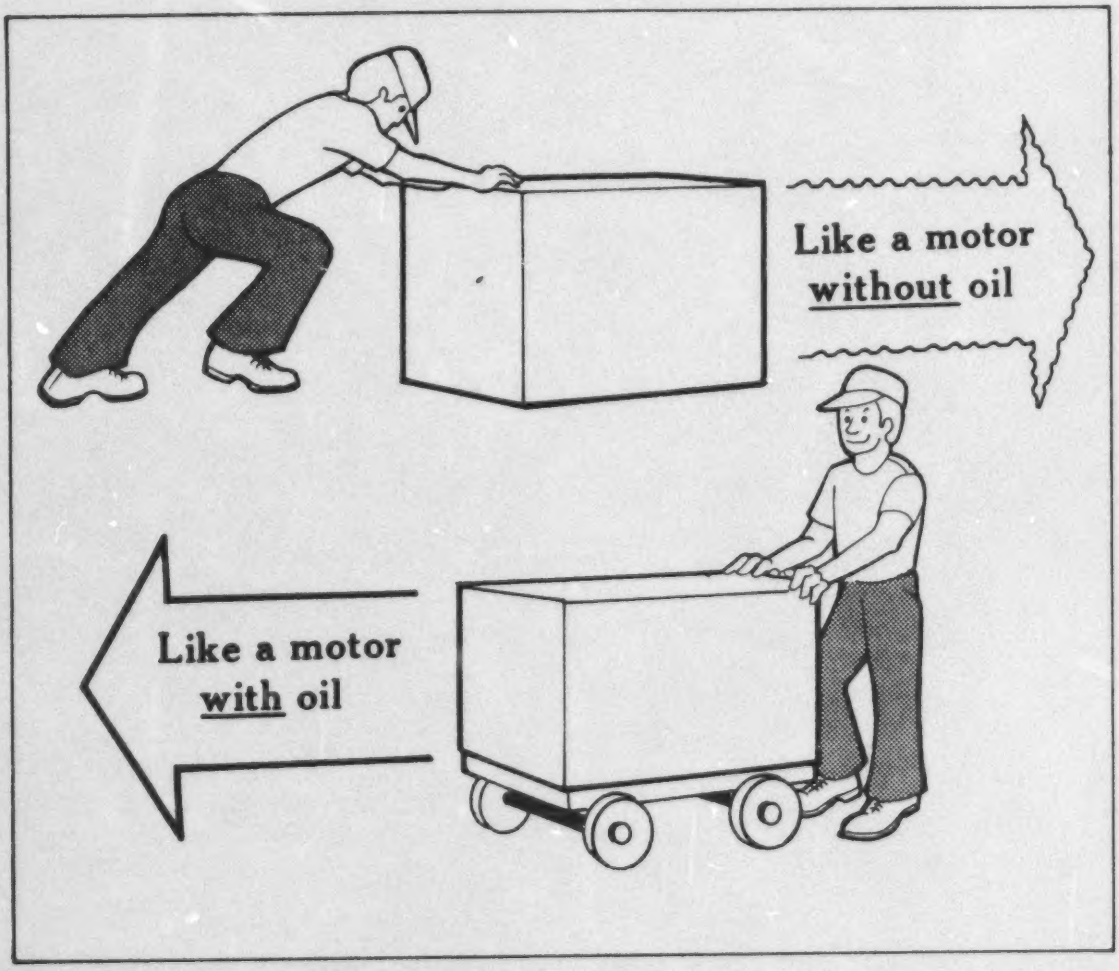


ONCE MISALIGNMENT STARTS 'EM FIGHTING EACH OTHER . . . THE ONLY QUESTION IS: WHICH WILL GO FIRST?

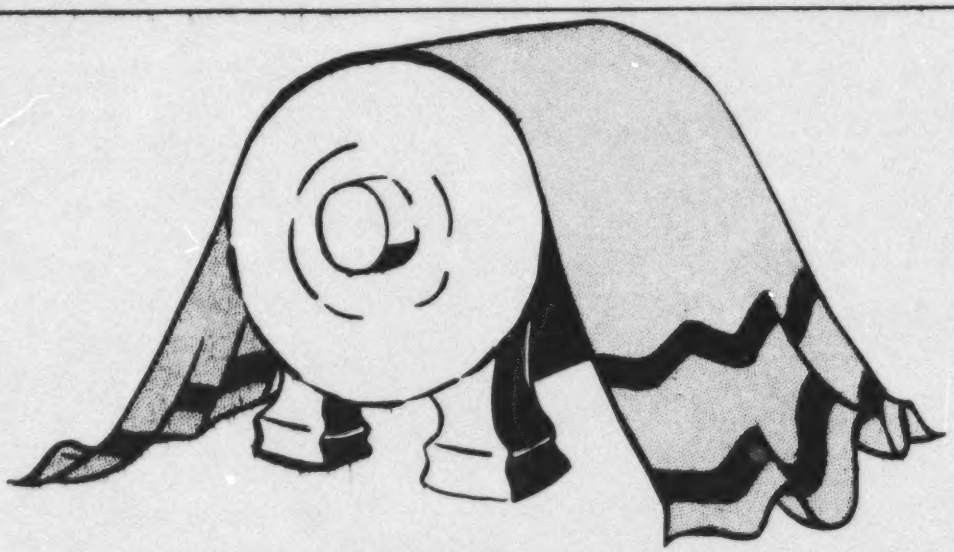
FRICTION



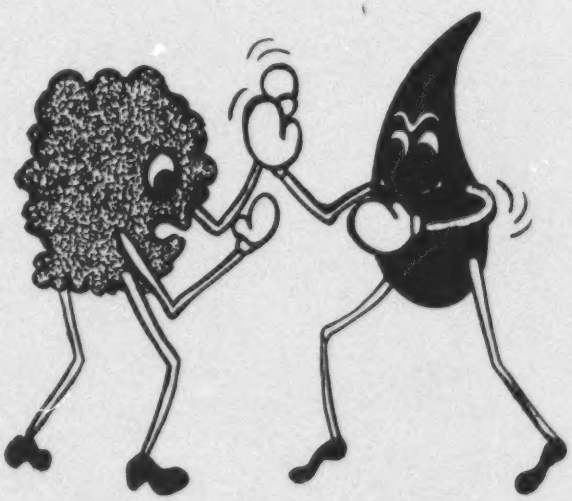
OIL REDUCES FRICTION



DUST



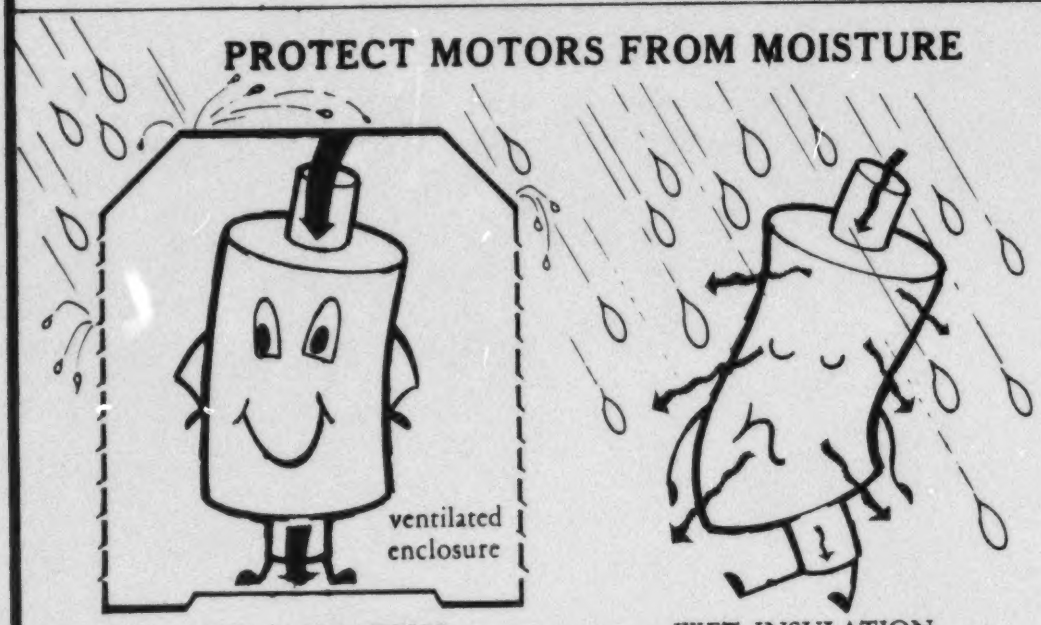
DUST ON ITS WINDINGS "BLANKETS" A MOTOR WITH A LAYER OF INSULATION



DUST FIGHTS LUBRICATION

MOISTURE

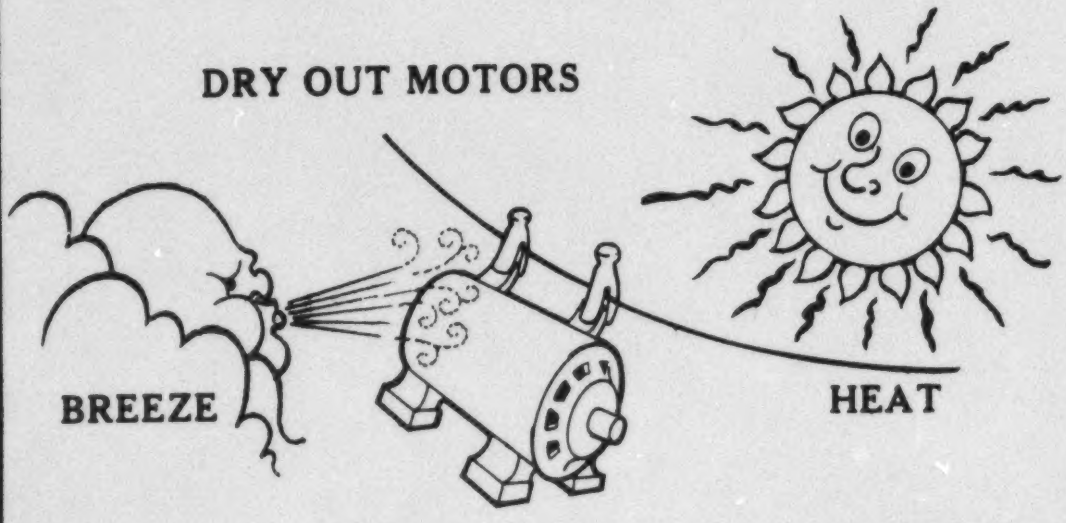
PROTECT MOTORS FROM MOISTURE



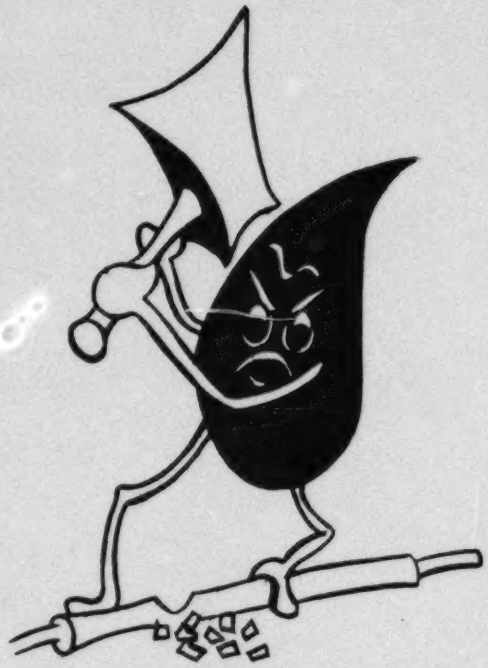
DRY INSULATION

WET INSULATION

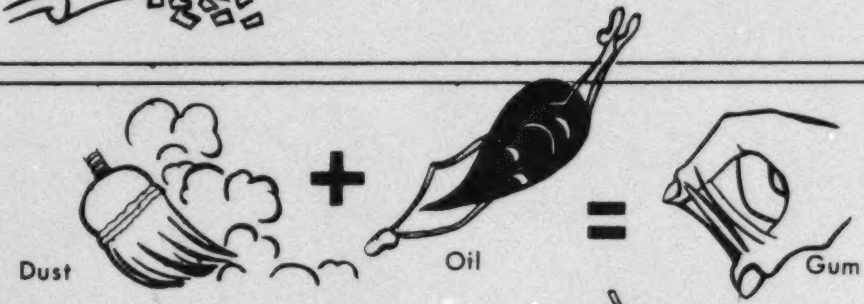
DRY OUT MOTORS

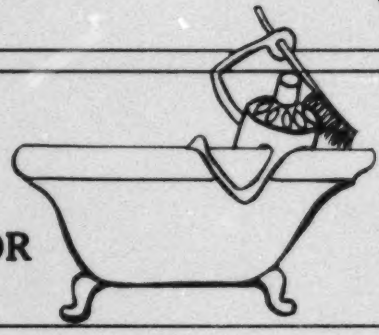


STRAY OIL



OIL IS QUICK TO ATTACK INSULATION WHEN IT GETS TO IT!





SOMETIMES A MOTOR NEEDS A BATH...

SPLIT - PHASE MOTOR PARTS

1. Motor Base
2. End Plates
3. Bearings
4. Rotor
5. Fan
6. Shaft
7. Centrifugal Mechanism
8. Starting Switch
9. Oil or Grease Fittings
10. Stator Windings
11. Protective Device

CONSTRUCTION AND MAINTENANCE

Unit E: Concrete

Topic 1: Estimating the Amount of Concrete Needed

Suggested Procedures and Activities: While discussing the topic, use several sample problems that will give the number sacks of cement and cubic yards of sand and gravel needed in certain sizes of concrete slabs, patio floors, barn floors, and foundations.

1. The Composition of Concrete

a. Concrete is a mixture of cement, water, and sand and gravel (aggregates) that form a hard stone after properly mixing in given proportions. Portland cement is manufactured from lime, iron oxide, silica, and alumina. These materials are mixed or blended in the proper proportions and heated in a kiln to about 3000 degrees F. A clinker is formed from the mixing and heating process, and then the clinker is pulverized into a fine powder (portland cement). After burning the compounds, gypsum is added to regulate the setting time. The term "portland" was first used in the early 19th century. Joseph Aspdin, founder of the present process, used the term because the cement he produced was the color of the stone taken from quarries on the island of Portland off the coast of England. Portland cement is usually packaged in sacks containing 1 cubic foot which weighs 94 pounds.

b. Aggregates (sand, crushed stone, and gravel) are usually considered as the basic filler material for a concrete mixture. Sand is considered as a fine aggregate (less than 1/4 inch) and gravel as a coarse aggregate (over 1/4 inch). Coarse aggregates are graded (uniform mixture of various size particles) so that they will give concrete the desired strength and be resistant to exposure conditions. Aggregates used for concrete mixtures must be free of dirt, silt or clay, coal, and organic matter. When mixing the proper proportions of cement, sand, and gravel, the finer aggregates fill in spaces between larger aggregates and each aggregate is surrounded by cement paste. Since aggregate in much cheaper than cement, the aggregate is a cost reducing material.

c. Water used in a concrete mixture should be clean and free of impurities such as silt, oil, and organic matter. Impurities may affect concrete strength coloration, corrosion of reinforcement steel and wire, and even setting time. For example, an excessive amount of sodium carbonate in the water may cause the mixture to set very rapidly, and salt water may affect the strength of concrete.

2. Quality of Concrete

a. Fresh concrete should have the following qualities:

(1) Consistency - Concrete mixes should be of a consistency suitable for the job. Plastic consistency mixes are required for most concrete jobs. Such a mix does not crumble but flows sluggishly without separation. A crumbly or watery mixture is not considered a plastic mix. Consistency of trial batches can be roughly measured by using the slump test. This test utilizes a slump core to determine how wet or how dry the mix is. A change in slump means the adding of sand and gravel to get the right consistency.

(2) Uniformity - In order to obtain a uniform mixture of concrete, the ingredients must be thoroughly mixed and distributed uniformly over a surface or area. Also, each mix on the same job should contain the same amounts of cement, aggregates, and water that were used in previous mixes. Non-uniform mixes may be of a different color, less or more resistant to wear, and less or more resistant to cracking.

(3) Workability - This characteristic of fresh concrete is determined by many factors such as the amount of water in a mix, the ratio between the sand and gravel, the size of coarse aggregates, and the type of location where the concrete is placed. The texture and structure of any concrete mix should lend itself to proper compaction and troweling.

b. Qualities desired in hardened concrete are:

(1) Durability - Durable concrete resists the action of freezing and thawing and the actions of chemicals. Cracking and scaling are usually caused by microscopic pores filling with water and then freezing. Durability can be improved by using the proper amount and clean ingredients, good workmanship in mixing, placing, finishing, and curing concrete. For example, damp curing will add to the durability.

(2) Strength - One test of strength is to crush a cylinder that is twice as long as its diameter in thickness after it has been cured four weeks. A cylinder is usually 12 inches long and 6 inches in diameter. The two better known factors affecting concrete strength are water-cement ratio and curing. Most farm structures are made by adding 5 to 7 gallons of water per sack of cement. The addition of water beyond this range tends to reduce the strength. Moist or damp curing of concrete for the first seven days may improve the strength 50 percent.

(3) Watertightness - Watertightness (ability to prevent water passage through its mass) is desirable in such structures as floors, troughs, and foundation walls. The water-cement ratio and length of curing time are definite factors affecting watertightness. For example, 5 gallons per sack of cement requires less time to cure than 7 gallons per sack of cement.

(4) Wear Resistance - This term applies to the ability of hardened concrete to resist abrasive action of traffic (wheeled vehicles, feet, flowing water). Also, most of the same factors that increase durability, strength, and watertightness increase the ability of concrete to resist wear. A very important factor that affects wear resistance is aggregate particles. Such particles should be hard and tough.

3. Advantages of Using Concrete and Agricultural Uses

The advantages of using concrete for agricultural construction are listed below:

Fire proof
Durable and permanent
Watertight
Economical
Can be "homemade"
Attractive
Termite and rodent proof
Storm resistant
Low maintenance
Sanitary
Readily adapted
Materials available locally

Agricultural uses of concrete include:

Fence posts
Water troughs
Walks
Driveways
Floors
Feeding troughs
Walls and foundations
Milk houses
Porches
Septic tanks
Cisterns
Culverts
Tile
Building blocks
Feeding floors
Manure pits
Silos
Steps
Tree surgery
Small bridges
Cattle guards
Barbecue pits
Setting posts
Drainage tile

4. Ready Mixed Concrete

a. Ready mixed concrete is sold by the cubic yard in various mixes. Most of the concrete used on large construction jobs is central-mixed; that is, the mixture is mixed in the proper proportion (cement, water, sand, and gravel) and delivered in an agitator (round concrete tank) mounted on the truck.

Some concrete producers use the transit-mixer (all mixing is done on the truck) or shrink-mixed method (mixing begins in a stationary mixer and ends in a truck mixer).

b. Advantages of using ready mixed concrete are:

(1) The concrete is thoroughly mixed; therefore, the concrete has the following characteristics: uniform quality, durability, and high strength.

(2) Materials such as cement, sand, and gravel do not have to be handled or stored on the job site. The figuring of the different quantities of these materials is eliminated.

(3) Less personnel is needed to handle a large concrete construction job.

(4) Concrete does not have to be mixed and poured in batches and it can be purchased in the exact quantity needed.

(5) The actual price of a job can be determined without having to figure waste in handling the materials.

(6) Admixtures (materials added to concrete mixtures other than cement, aggregates, and water that give concrete desired qualities) can be added to the concrete mixture during mixing or even added to cement before mixing. Types of admixtures are:

(a) Air - Entraining - Several hundred small air cells are dispersed through the cubic yard of concrete. These cells protect the concrete during freezing and thawing.
(b) Water-Reducing - If the water is reduced in certain mixes, the strength of the concrete is usually increased. The rate of slump may or may not be reduced by using water-reducing admixtures.
(c) Retarding - These types of admixtures retard the setting time of concrete. They are very beneficial when high temperatures cause concrete mixture to harden at a fast rate.
(d) Accelerating - Calcium chloride added to the mixing water causes concrete to set up in a shorter period of time than mixtures that do not contain the chemical.
(e) Pozzolans (agents to control expansion of certain aggregates and heat), workability agents, and dampproofing agents - These and other agents are added as admixtures.

c. The following procedures may be used to estimate the quantity of ready-mixed concrete needed and allowing for about 10 percent waste:

(1) When ordering mixtures by numbers the following example may be helpful:

6-6-6 stands for 6 sacks of cement per cubic yard, 6 gallons of water per sack of cement, and 6 percent entrained air.

(2) Determine the surface area (length times width) and then determine the number of cubic yards of concrete needed using the figures listed below:

Concrete Thickness	Divide area by:
1 inch	300
3 inches	100
4 inches	75
6 inches	50
12 inches	25

Example: A slab, 20' x 40', 4 inches thick -

20 x 40 = 800 square feet

$\frac{800}{75}$ = 10.66 cubic yards of mix.

5. Determining the Amount of Materials Needed

Transparencies Nos. 1, 2 and 3

A volume of materials (cement, sand, gravel, and water) needed for a given volume of finished concrete must be calculated in order to produce the proper mix. Another reason for figuring the amount of each solid to use is that the particles of solids are of different sizes and the smaller particles fill spaces between large particles.

a. Three recommended mixes by using different quantities of water are:

(1) 5-Gallon Mix - For acid or alkaline resistant; walks, fence posts, flower boxes, and thin work.

(2) 6-Gallon Mix - Watertight; floors, tanks, walls; all reinforced concrete.

(3) 7-Gallon Mix - Foundation walls, retaining walls; underground concrete; no water pressure concrete.

b. The amount of water in the sand should be considered and included when measuring the amount of water for a mixture. For example, a 5-gallon mix should contain a total of 5 gallons of water, including the water in the sand. In order to estimate the amount of sand moisture a small quantity of sand is pressed into a ball in the hand.

(1) Damp Sand - (1/4 gallon of water per cubic foot) Falls apart when the hand is opened.

(2) Wet Sand - (1/2 gallon of water per cubic foot) Ball of sand holds its shape when the hand is opened.

(3) Very Wet Sand - (3/4 gallon of water per cubic foot) Ball is formed and leaves hand wet when the hand is opened.

c. The volume or amount of cement, sand, and gravel may be determined by using "Fuller's" rule. This rule states that the mixing of a total of 42 volumes of cement, sand, and gravel will produce 27 volumes of concrete. The following problem illustrates the use of Fuller's rule:

Using a 1-2 1/4-3 mix, determine the number of sacks of cement, cubic yards of sand, and cubic yards of gravel that will be needed to build a sidewalk 4 inches thick, 6 feet wide, and 100 feet long.

6' x 100' x 4" = 6' x 100' x 1/3' = 200 cubic feet of concrete required.

Fuller's Rule

$\frac{200 \times 42}{27}$ = 311 cubic feet of raw materials

Mix is -

*1 part cement = 1
2 1/4 parts sand = 2.25
3 parts gravel = 3
6 1/4 or 6.25 total volumes of mix

$\frac{311}{6.25}$ = 49.76 or 50 sacks of cement

$\frac{50 \times 2.25}{27 \text{ cu. ft. or 1 cu. yd.}}$ = 4.17 cu. yds. sand

$\frac{50 \times 3}{27 \text{ cu. ft. or 1 cu. yd.}}$ = 5.55 cu. yds. gravel

*1 sack of cement = 1 cu. ft. and weighs 94 pounds

6. Mixing Concrete

The proper measurement of materials plus water and proper mixing insure production of uniform batches of concrete of good quality. The two common methods used for mixing concrete are:

a. Machine Mixing

(1) Add up to about 10 percent of the water needed before adding any solids. After the water is in the mixer, it should be started or put into operation.

(2) Add a portion of the gravel as the second operational step. Adding the gravel at this stage of operation provides a scouring action which aids in mixing the paste.

(3) The third operational step is to add the measured amount of cement required for the batch to be mixed.

(4) Add sand and the remaining amount of gravel needed and then add the remaining 10 percent of the water uniformly in the drum until the proper consistency is obtained.

(5) Operate the machine from 1 to 3 minutes. A two-minute mix is usually more thoroughly mixed than a one-minute mix. Concrete usually looks drier in a drum than it does outside the drum; therefore, it is necessary to add recommended portions of each ingredient.

b. Hand Mixing

(1) Place sand in the mixing container, then add cement and mix the two materials thoroughly. Add gravel and continue mixing the materials.

(2) Add measured amounts of water and mix well. If the consistency is improper, add a small amount of sand or gravel or sand and gravel. Hand mixing is usually done in a wheel barrow or concrete mixing box and the measuring tool is a shovel.

References:

1. "Concrete Technology Student Manual", Delmar Publications, Albany, New York.

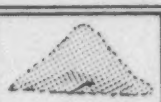
2. "Design and Control of Concrete Mixtures", Portland Cement Association, Skokie, Illinois.

3. "Concrete - Suggested Lesson Plans for Teachers of Vocational Agriculture", Portland Cement Association, Austin, Texas.

4. "Concrete Improvements Around the Home", Portland Cement Association, Skokie, Illinois.

DETERMINING AMOUNTS OF MATERIALS

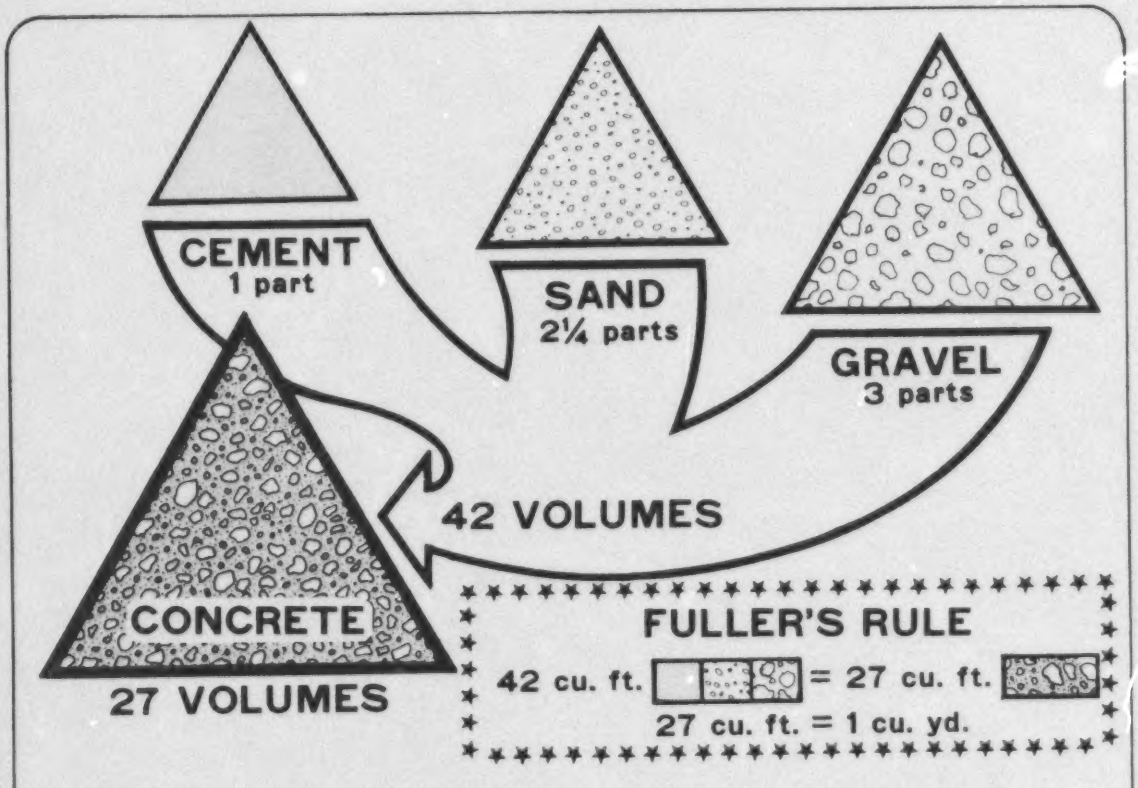
USE OF WATER IN TRIAL BATCH MIX

CEMENT (per sack)	 SAND (cu. ft.)	GRAVEL (cu. ft.)	WATER NEEDED (in gallons)			
			dry sand	damp sand	wet sand	very wet sand
1	1¾	2	5 gal.	4½ gal.	4 gal.	3¾ gal.
1	2¼	3	6 gal.	5½ gal.	4½ gal.	4 gal.
1	2¾	4	7 gal.	6¼ gal.	5½ gal.	4¾ gal.

MOISTURE IN SAND

DAMP SAND	◊ Falls apart	◊ ¼ gal. per cu. ft.
WET SAND	◊ Ball holds shape	◊ ½ gal. per cu. ft.
VERY WET SAND	◊ Sparkles, wets hand	◊ ¾ gal. per cu. ft.

DETERMINING AMOUNTS OF MATERIALS



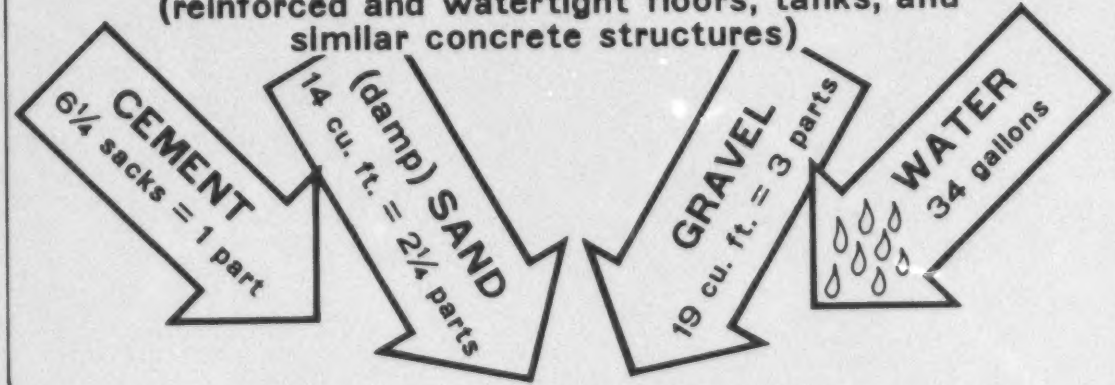
FULLER'S RULE

42 cu. ft. = 27 cu. ft.

27 cu. ft. = 1 cu. yd.

RECOMMENDED MIXTURE FOR MEDIUM WEAR

Use a 1—2¼—3 mixture for 1 cu. yd. of concrete (reinforced and watertight floors, tanks, and similar concrete structures)



= 1 cu. yd. CONCRETE MIX

PROBLEM

➤ **Use 1—2¼—3 mix to build 4" thick, 6' wide, and 100' long.**

$$\frac{6' \times 100' \times 4''}{12''} \text{ OR } \frac{6' \times 100' \times \frac{1}{3}'}{1'} = 200 \text{ cu. ft. of concrete required}$$

$$\frac{200 \times 42}{27} = 311 \text{ cu. ft. of raw materials}$$

$1 + 2\frac{1}{4} + 3 = 6\frac{1}{4}$ volumes of mix

OR

$1 + 2.25 + 3 = 6.25$ volumes of mix

$$\frac{311}{6.25} = 49.76 \text{ or } 50 \text{ sacks of cement}$$

$$\frac{50 \times 2.25}{27 \text{ cu. ft./yd.}} = 4.17 \text{ cu. yds. sand}$$

$$\frac{50 \times 3}{27 \text{ cu. ft./yd.}} = 5.55 \text{ cu. yds. gravel}$$

CONSTRUCTION AND MAINTENANCE

Unit E: Concrete

Topic 2: Construction of Forms and Reinforcing

Suggested Procedures and Activities: If it is not possible to demonstrate form building or have students construct forms for concrete foundation and structures, is may be necessary to visit a building site where forms are already constructed.

1. The Purpose of Forms

Concrete, being a plastic construction material, must be confined to a certain area to harden. The most common types of form material consist of wood, metal, plywood, and plastic. Sometimes earth trenches are also used as a form structure, if they are firm enough to maintain a desired shape. Footings for certain types of buildings are poured in earth trenches.

Small houses and other farm structures may require foundations or footing that contain over 30 yards of concrete weighing upward of 60 tons. If this amount of weight is to be held in place without shifting, well constructed forms must be used. Regardless of the weight or amount of concrete used, good forms will help add to the appearance of structures or parts of buildings where concrete is exposed. The design of the form may add to the ease of finishing a surface.

2. Design and Construction of Good Forms

Transparencies Nos. 1 and 2

a. Forms must be designed of materials (lumber, pressed wood, or metal) that will give the desired texture to exposed concrete. Wooden forms should be treated with some type of parting agent such as oil or lacquer so that they can be easily removed. They should also be moistened just before placing the concrete. Dry wood forms will absorb concrete moisture and swell after the concrete is placed, and this may cause the structure to be slightly irregular in places.

Forms must have the following characteristics:

Constructed to give the surface the proper grade or slope. Clean and free of knots, protruding nails, and cracks. Tight at all joints. Well staked and braced to prevent bulging, sagging, and spreading. Plumb, correct size, and shape.

b. In constructing concrete forms it is necessary to keep in mind the following factors:

(1) Concrete Weight - The weight is more or less the same unless light weight aggregate (ground stone or rock) is used.

(2) Pouring Rate - If concrete is poured slowly, it may have time to set up and reduce the pressure on the forms. If the rate of pour is fast, the forms will require more bracing, wales (horizontal supports), and form ties.

(3) Temperature - If the concrete and surrounding temperature is low the concrete remains in a liquid state longer than when the temperature is high; therefore, more strain is placed on the forms. The ideal temperature range is from 50 to 70 degrees for most concrete mixes.

(4) Placement - The use of vibrators tends to keep concrete in a fluid state the full depth of the structure; again, more pressure is placed on the forms.

c. Methods and materials used in constructing forms include:

(1) Lumber or Boards - Foundation, floor, and walk forms are usually made with finished lumber that has been treated with oil on the inside to keep concrete from sticking.

(2) Plywood or Hardboard - These materials are used to obtain a smooth finish or surface. This type of material must also be painted with oil or lacquer to prevent concrete from sticking to the surface.

(3) Sheet Metal and Other Metals - Strips of sheet metal should be used to round off sharp corners and angles to make a stronger and neater job. Metal is also used as a support for plywood frames.

d. The main parts of a standard form include:

Wall	(Wall or	Studs
Wales	Foundation	Spreader blocks
Wire ties	Form Parts)	Stakes and braces
Stud ties		

Forms for concrete slabs (walks, floors, and drive areas) usually have stakes, braces, and wall board. Two-inch lumber is used for this type of form construction; 2" x 4"s and 2" x 6's of various lengths are the common sizes used for agricultural purposes. Wall and foundation forms are constructed of lumber and plywood from 3/4" to 4" thick. Panel forms constructed either on the site or elsewhere may be used for several jobs of the same dimension, or the panels may be dismantled and used in building the structure.

e. Some items of importance when constructing forms include:

(1) In addition to joining the forms with nails and wood bracing at strategic points, wire ties (10 or 12 gauge) that extend from one wall to the other should be tightened against wood spacers. Spacers may be removed as the concrete is placed.

(2) If plywood or hardboard is not used in form construction, then tongued-and-grooved boards should be used. The leaking out of water and grout (sand and cement) may leave a honeycombed surface.

(3) Forms can be constructed by using almost any type of nail, but a double head nail is very popular due to the ease in removing when salvaging the lumber. The collar on this nail keeps the head clear of the wood, making it easy to remove with a wrecking bar or claw hammer.

(4) In certain cases it may be as cheap to use prefabricated forms including manufactured ties as building forms and using plain wire ties. Builders and contractors may be in a position to rent or lease prefabricated forms for certain types of construction.

f. Removing forms is another construction job where concrete is involved. The following things should be considered when moving forms:

(1) In warm weather, forms should remain in place two or three days or until the concrete has set and cured to a certain extent. Forms should remain in place twice as long when the weather is cold.

(2) Forms left in place for at least a week aid the curing process by protecting the concrete from drying too rapidly.

(3) The nature of work may also determine the length of time to let the forms remain in place. For example, if the construction is to be rubbed or finished before the concrete becomes too hard, it will be necessary to remove the forms.

3. Reinforcing Concrete

Transparencies Nos. 3 and 4

a. Concrete is weak in tension or bending, but it is strong in compression. If the tensile strength is to equal or exceed the compressive strength, then concrete must be reinforced. The compressive strength may be ten times the tensile strength.

b. There are two kinds of reinforcement materials used on most concrete jobs. Both materials are made of steel. The two kinds of reinforcement materials are:

(1) Bars - Small diameter bars are usually smooth and large diameter bars deformed. The size, area, and weight of bars, designated by number, are listed below:

Diameter in Inches	Wt. per 100 Feet	Bar Number
1/4	17	2
3/8	38	3
1/2	67	4
3/4	150	6
1	267	8

The amount of tensile force supported by concrete depends largely on size of bars used. Bar length supplied by lumber yards is 20, 40, and 60 feet. Bars are almost always used for foundations.

(2) Welded Wire Fabric - This type of reinforcement material is used extensively for slab jobs. The common sizes vary from 6 to 8 gage material with wires spaced on centers of six inches. The styles and weights are listed as follows:

Wire Style	Pounds per 100 Feet
6x6 No. 6	42
6x6 No. 8	30
6x6 No. 10	21

c. Proper placement of reinforcement steel is very important. Methods of placing include:

(1) Covering Reinforcement - Steel bars and wire fabric should be placed in concrete at a depth that will give the concrete the maximum strength and protect the steel from exposure. For example, minimum coverage for members are:

Minimum Coverage	Member
3 inches	Footings
3/4 inch	Slabs and walls
1 1/2 inches	Beams
At least 1 1/2 inches	Columns
2 inches for No. 5 Bars 1 1/2 inches for bars smaller than No. 5	(concrete exposed to weather)

(2) Splicing Bars and Wire Fabric and Tieing Bars - Steel bars are lapped to give the tensile strength needed. Deformed bars must be lapped at least 12 inches, and smooth bars should be lapped at a greater distance. Wire fabric is usually lapped one and one-half square. A 6-inch mesh (6-inch center fabric) would be lapped about 9 inches. Laps of both bars and wire fabric are tied to keep the reinforcement in place. Steel bars laid for slabs (floors, driveways, and walks) is usually placed to make squares. Example: Floor slabs 4 inches thick may require 16-inch squares. Each square may or may not be tied.

d. Rules for reinforcing concrete are:

(1) Use clean steel (free from rust, paint, tar, and scale).

(2) Place steel as recommended in C-(1)

(3) Lap deformed bars a minimum of 12 inches or 24 bar diameters. For example, a 1/2-inch bar would be lapped 12 inches.

(4) Place reinforcement where concrete needs the greatest tensile strength and at all corners and joints.

(5) Position reinforcement material as near the center of depth as possible for slab jobs.

(6) Use bar chairs and slab bolsters to make the work easier and give the concrete better strength.

References:

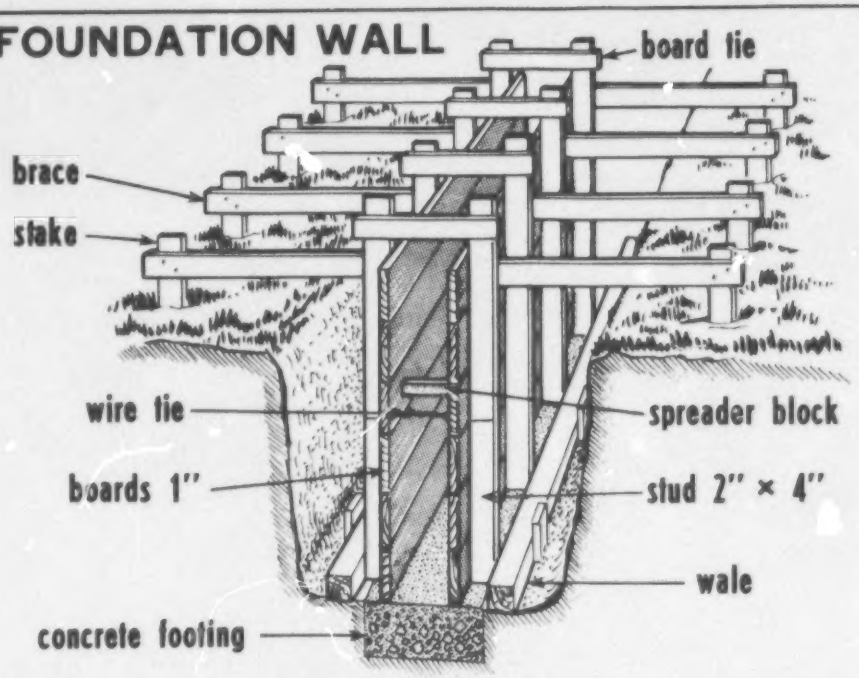
1. Phipps, Lloyd J., Mechanics In Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois.

2. "Concrete Technology", Delmar Publishers, Albany, New York.

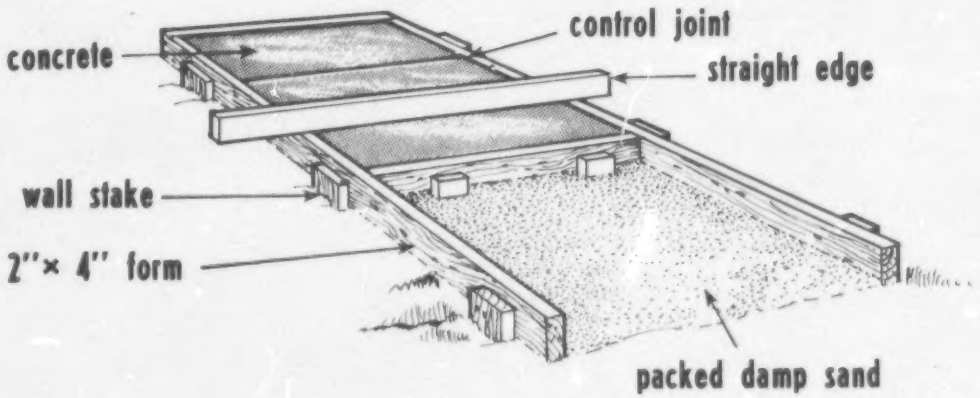
3. "Design and Control of Concrete Mixtures", Portland Cement Association, Skokie, Illinois.

DESIGN AND CONSTRUCTION OF GOOD FORMS

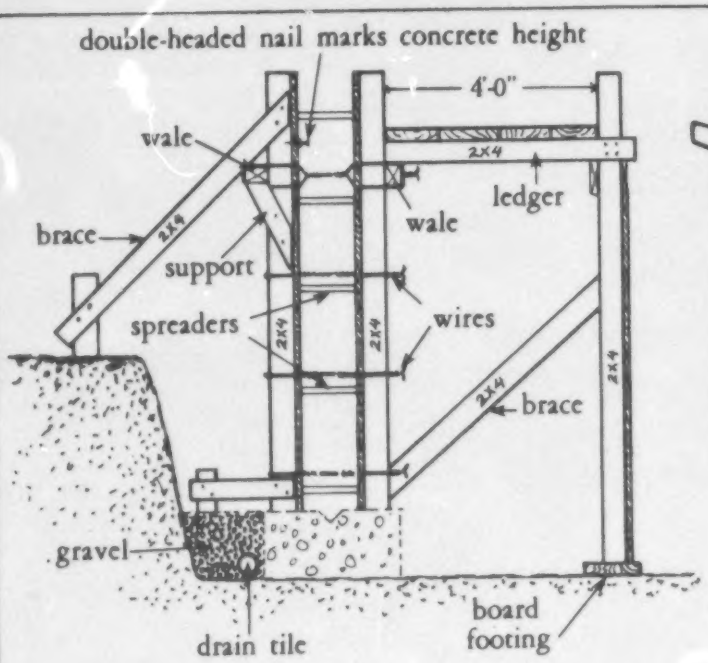
FOUNDATION WALL

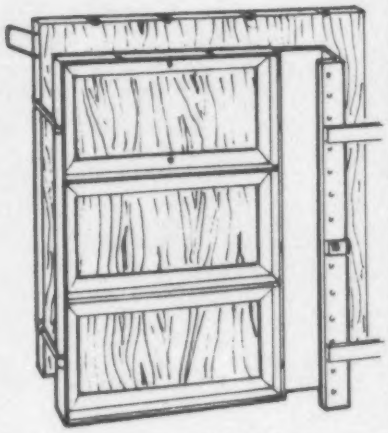


CONCRETE SLAB (walk)

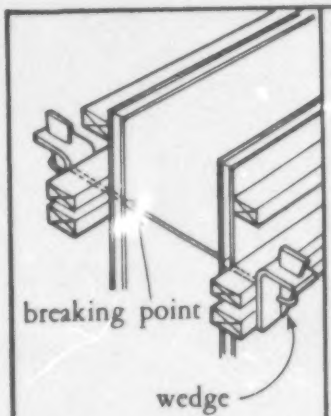


FORMS AND TIES

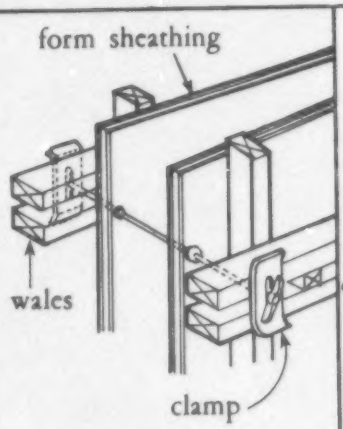




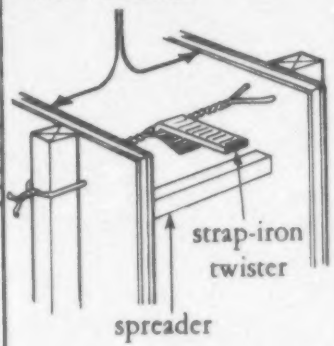
MANUFACTURED PANELS FOR FORMS



SNAP TIE

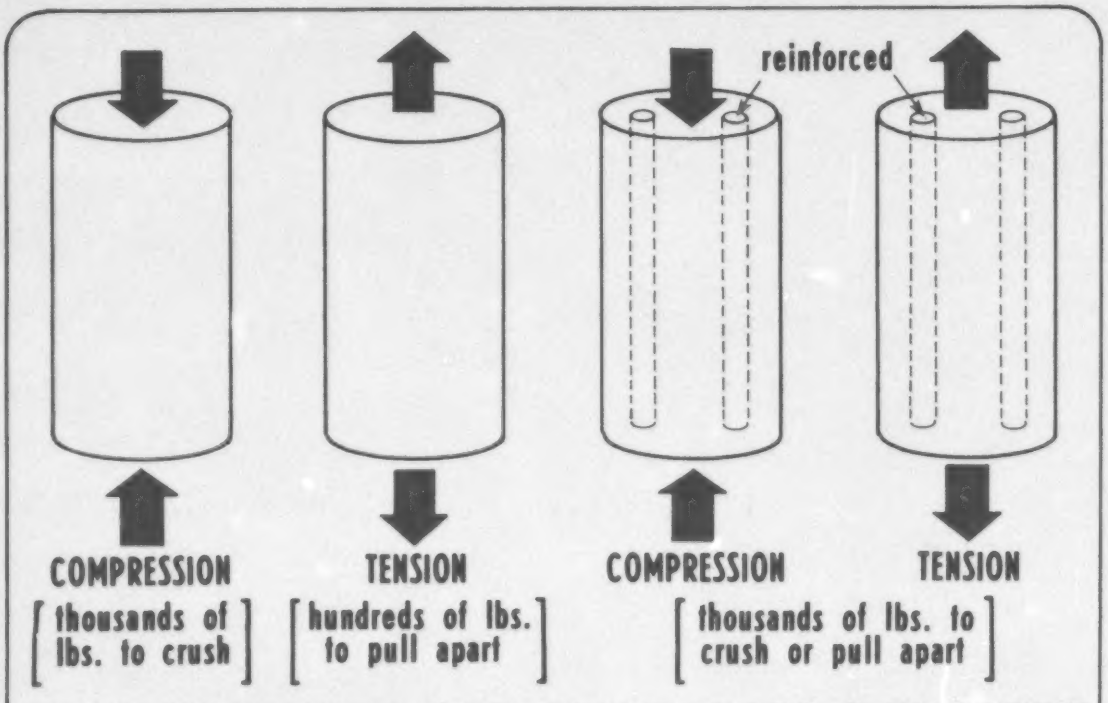


SNAP TIE

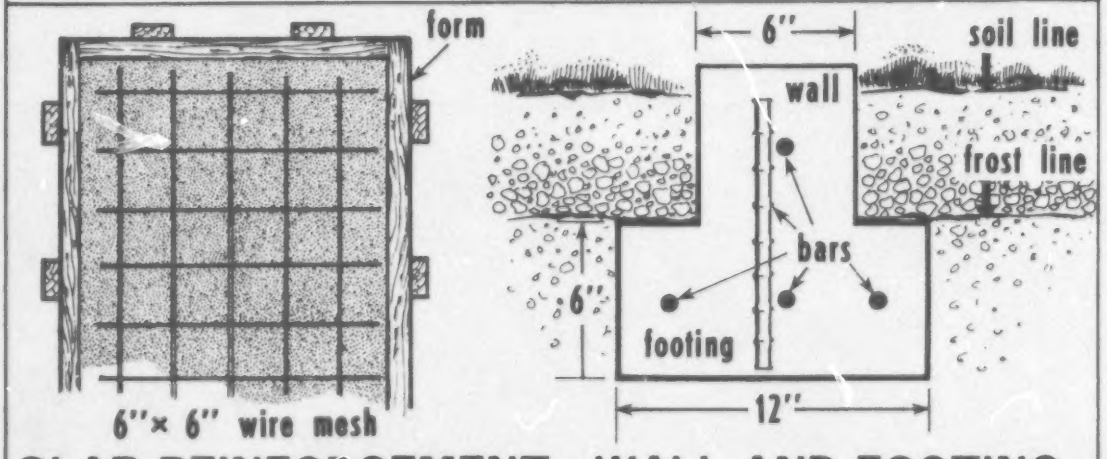


WIRE TIE

REINFORCING CONCRETE

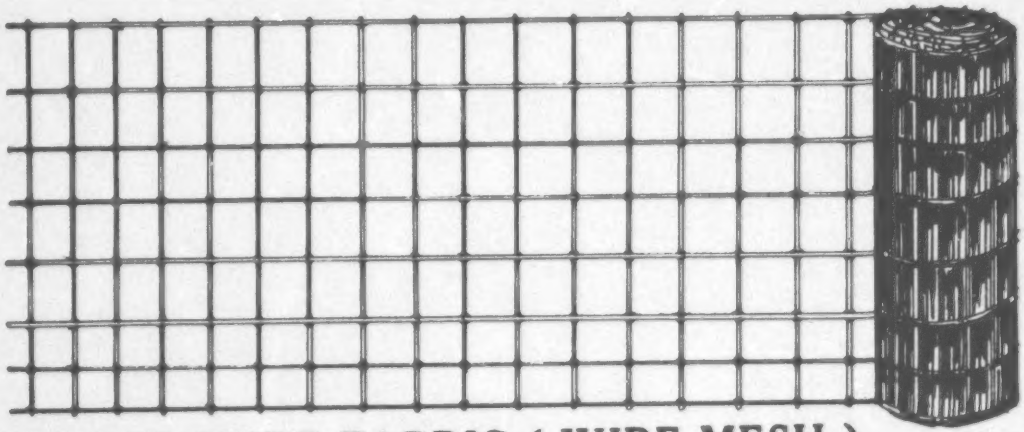


NONREINFORCED AND REINFORCED CONCRETE

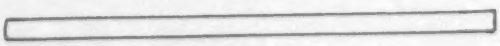


SLAB REINFORCEMENT • WALL AND FOOTING

KINDS OF STEEL REINFORCEMENT



WELDED WIRE FABRIC (WIRE MESH)



SMOOTH STEEL BAR

DEFORMED STEEL BAR

Size, Area, and Weight of Some Reinforcement Bars

Bar No.	Diameter	Bar Area sq. inches	Wt. per 100 ft.
2	1/4	0.05	17
4	1/2	0.20	67
6	3/4	0.44	150
8	1	0.79	267

CONSTRUCTION AND MAINTENANCE

Unit E: Concrete

Topic 3: Placing, Finishing, and Curing Concrete

Suggested Procedures and Activities: The use of a filmstrip titled "Placing, Finishing, and Curing Concrete Slabs", will be helpful while discussing the topic. A lab trip to a site where concrete is being placed and finished will also serve as another learning method.

1. Placing the Concrete

   a. After the subgrade is prepared, the forms set, and reinforcement bars or wire mesh are installed, concrete should be placed in its final position or as near as possible.

   b. Slabs should be constructed by placing the concrete near one edge at the end of the work, and each batch should be poured against the other. Concrete should not be dumped in piles and the piles worked together. If large piles are dumped and the concrete moved horizontally to its final position, the finer materials will move ahead, leaving the coarser materials (gravel) behind.

   c. When walls are poured, the first batches are poured at either end and worked toward the center. This practice will help eliminate water collecting at the ends and in corners. If possible, concrete should be placed in horizontal layers of uniform thickness. It can be placed in 6 to 20 inch layers and properly distributed.

   d. Concrete placed in tall forms has a tendency to be watery (bleeding of water) at the top surface. Bleeding may be reduced by placing the concrete more slowly or by using air-entrained or stiffer consistency mix.

   e. When placing concrete on a slope, placing is begun at the bottom first and the forms are filled by working up the slope.

   f. Tamp and spade mixtures thoroughly to eliminate air pockets, and work the concrete against the side of the forms so that large aggregate will be forced away from forms to leave a smooth surface.

   g. Vibration is used in placement of stiff concrete mixes. If a mix can be worked with hand tools, it should not be vibrated. If soft mixes are vibrated, the aggregates will separate from the water. Some advantages

of using concrete vibrators on stiff and harsh mixes are:

(1) Increased strength, watertightness, resistance to adverse weather conditions, and a good bond between concrete and reinforcement.

(2) Less bulging of form walls and less volume change.

(3) Earlier finishing of the surface.

h. Slightly overfilled forms will help control bleeding if the concrete is allowed to begin stiffening before the excess is cut off. Also, it is considered a better practice to cut excess concrete from a form than to continue adding as the mix begins to set.

2. Finishing Concrete

Transparencies Nos. 1, 2, 3, and 4

a. As soon as the concrete is poured it should be screeded (struck off bringing the top surface to the proper grade). For narrow surfaces such as small floor slabs and walks, a 2 x 4 or 2 x 6 held on the edge and moved back and forth in a sawing motion may be used to fill in low places and remove the excess concrete. For large areas special made templets should be used. An excess of concrete should be present at all times in front of the templet as it is moved laterally. A bull float should be used to remove ridges left by the templet. Smoothing action is done by raising the front of the float on the forward motion and dragging it back with the blade flat on the pulling stroke.

b. After the water sheen has disappeared and the concrete has stiffened enough that only a slight imprint is left by the foot and body weight, then the concrete is ready to float and trowel. The purposes of floating are:

(1) To impact the concrete at the surface and make it easier for the finishing jobs.

(2) To embed large aggregate particles below the surface.

(3) To remove high and low places on the surface.

c. Troweling gives the concrete a smooth dense surface. This finishing job should follow floating and it should be done when the concrete is at the proper stage of dryness. Premature troweling like premature floating will likely cause dusting, crazing, and scaling of concrete. Such a surface has a reduced wear resistance. If water appears while troweling, it should not be sprinkled with dry cement; neither should water be sprinkled on concrete that appears hard. When troweling follow the suggested procedure:

(1) Hold the trowel flat when passing over the surface the first time. Tilt the trowel blade slightly and apply pressure when passing over the surface the second time. A tilted blade may give a "washboard" effect on the first troweling; therefore, it must be held flat.

(2) Make an arc motion with the trowel and overlap each pass at least one-half on each sweep.

d. Edging and jointing are usually done before or after concrete is troweled. Usually edging and grooving tools are used before the concrete hardens or while it is still plastic. Edging serves two purposes; it prevents chipping when removing the forms and gives the edges of slabs a chip-free surface. Jointing forms a weakened area that causes cracking to remain in the jointed groove instead of irregular cracking in other areas of a slab.

(1) The edging procedure includes:

(a) Hold the edges flat as back and forth passes are made. On the forward stroke add pressure on the back, and on the backward stroke add pressure on the front (in front of the hand).
(b) Keep the curved part of the edger against the form as it is moved back and forth. Like troweling there should be no water sheen when edging.

(2) The jointing procedure is as follows:

(a) Use a brick trowel or hatchet to make a slight cut if the concrete is too hard to start the jointer. For large jobs, power equipment is used to cut joints.
(b) Cut joints in walks and driveways using a long straight edge (board) as a guide for the jointer.
(c) Hold one edge of the jointer against the straight edge and apply pressure to the handle as the tool is pushed forward.

e. Concrete may be floated after it is edged and jointed. If it is to be exposed to use by walking or machinery, it should be finished with a wooden trowel. A metal trowel tends to bring a thin film of cement to the surface making it slippery and less resistant to wear. If a metal trowel is used, a broom can be used to remove the glazed surface. Brushing is done at a right angle to traffic. The use of burlap covering immediately following the floating will also give a slightly rough finish.

f. Types of finshes are:

Transparency No. 5

Type	Use	Obtained By
Gritty-non-slipping or scored surface	Walks, barn floors, driveways, and ramps	Using wood float, stiff broom, or burlap covering
Smooth, troweled finish	Feed troughs, certain type of floors	Using steel trowel
Pea grain or exposed aggregate	Porches and patios	Washing with water hose

3. Curing Concrete

Transparency No. 6

a. A chemical reaction takes place in the curing of concrete. Tobermorite gel and other products are formed in the reaction between cement and water. As hydration proceeds gel increases, making the mixture stronger.

b. About 3 gallons of water are used to hydrate each sack of cement in a batch. Freshly mixed concrete contains much more than this amount of water, but unless the mixture is protected after placing much water is lost through evaporation and seepage.

c. Since the presence of moisture in the concrete mixture causes the hydration process to continue, it is necessary that precautions be taken to prevent the water from evaporating. The strongest concrete is moisture cured. Proper curing does not only increase the strength but it adds to the durability and watertightness of the finished product. A 28-day cure is much stronger than a 7-day cure. Concrete that is moist-cured for 7 days is 50 percent stronger than simply air dried concrete.

d. Concrete can be moist cured either by sealing the surface or by adding water to the surface. These methods may include:

(1) Use of plastic, waterproof paper or spraying with a chemical membrane to seal the surface.

(2) Covering with a wet material and keeping the material moist. Some of the more popular materials are burlap- canvas, sand, shavings, or straw. Also flooding and holding water on the surface is used. Regardless of the methods used, concrete should be cured for a minimum of 6 days.

4. Problems Encountered and Preventative Measures

Scaling (When Surface Breaks Away From Slab)	
Causes	Preventative Measures
Early cycles of freezing and thawing of the surface of newly placed concrete	Keep the temperature of freshly placed concrete about 50 degrees for at least 5 days.
Faulty workmanship in any one of the finishing operations, screeding, troweling, or floating, performed while free water is on the surface	Do not perform any finishing job when free water is present on the concrete.

Crazing (Fine Hair Cracks on Surface)	
Rapid surface drying usually caused by either hot sun, dry winds, or hot air temperatures	Apply spray fog or cover with burlap immediately after striking off excess concrete. Keep surface covered with burlap until ready for floating.
Premature floating and troweling; working when there is excessive moisture	Do not start floating and troweling until excess moisture has evaporated and concrete has started to "set".
Overuse of the jitterbug, vibrator, or bull float may contribute by working excess moisture to the surface.	Use the finishing tools sparingly.

Dusting (Powdery Material on Surface)	
An excess amount of clay or silt in the concrete. These mix with the sand and cement at the surface.	Use clean and well-graded fine and coarse aggregate.

Premature floating and troweling	Delay until all free water has evaporated.
Carbon dioxide from gasoline engines. When this happens a reaction takes place that impairs proper hydration.	Provide adequate ventilation.
No curing or inadequate curing	Proper curing for the specified length of time. Improperly cured concrete will wear easy by foot traffic.

References:

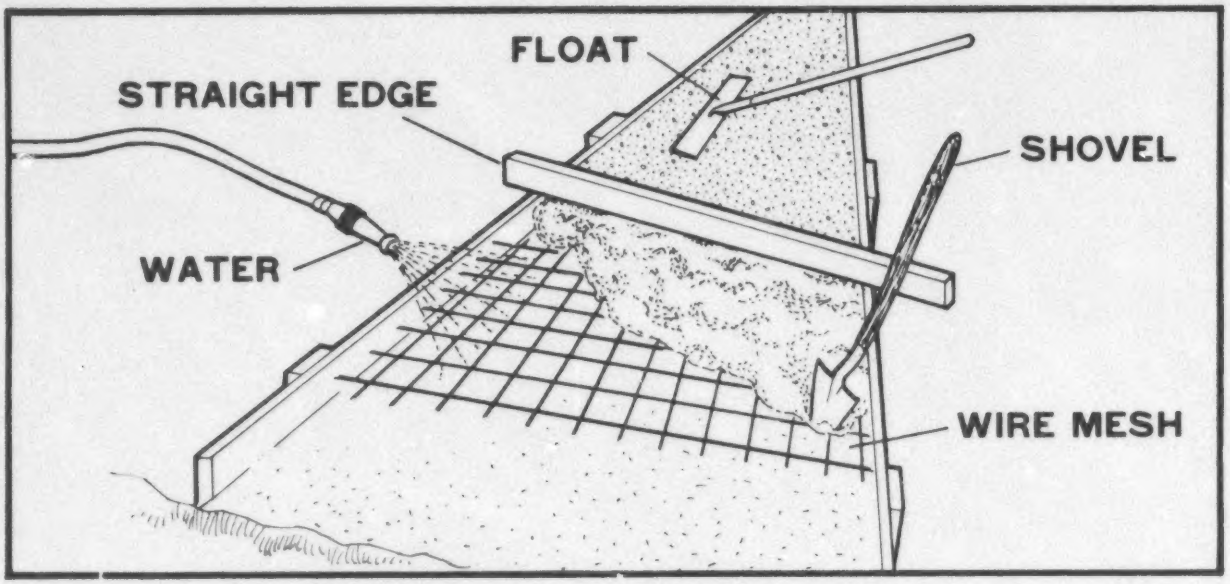
1. Ahrens, Donald L., and others, Concrete and Concrete Masonry, Hobar Publications, Division of Hobar Enterprises, Inc., St. Paul, Minnesota.

2. "Concrete Technology", Delmar Publishers, Albany, New York.

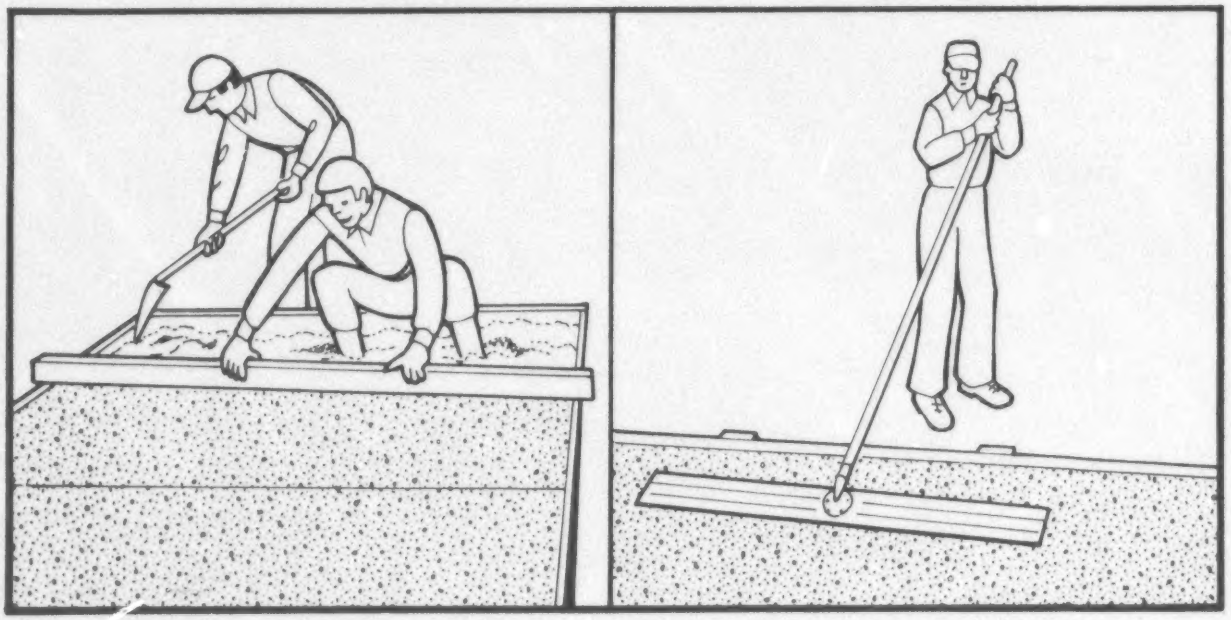
3. "Design and Control of Concrete Mixtures", Portland Cement Association, Skokie, Illinois.

4. "Concrete Improvements Around the Home", Portland Cement Association, Skokie, Illinois.

FINISHING CONCRETE



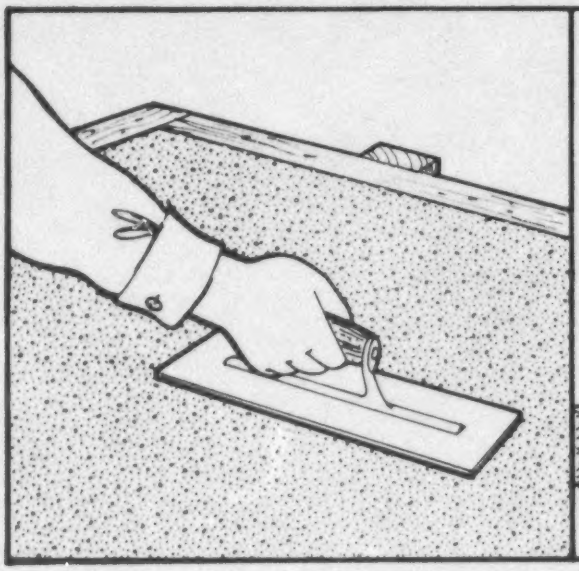
PLACING AND FINISHING WALK



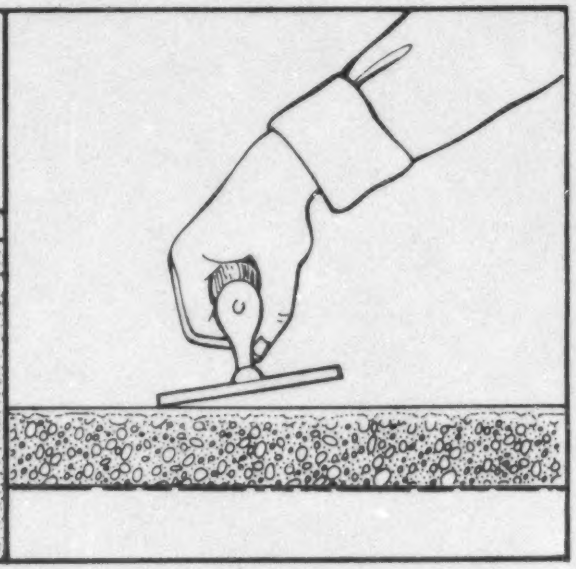
SCREEDING

BULL FLOATING

FINISHING CONCRETE

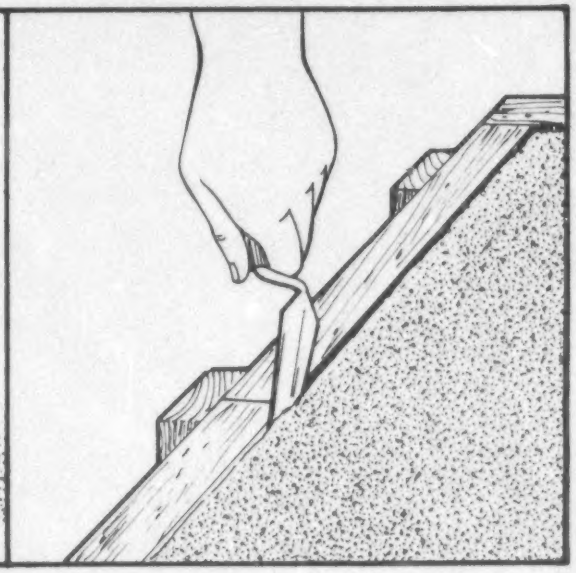


TROWELING FLAT



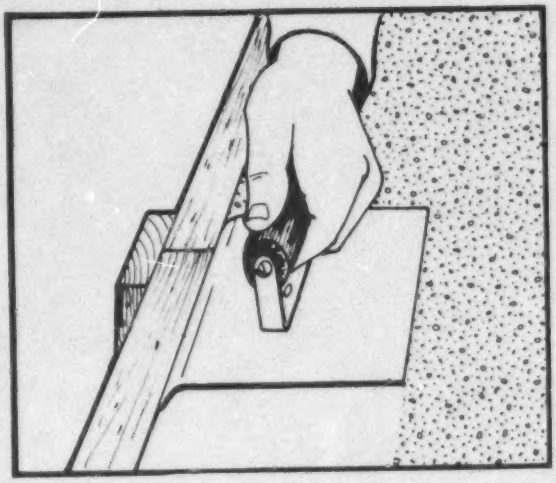
TROWELING TILTED

MAKING ARC SWING WITH TROWEL

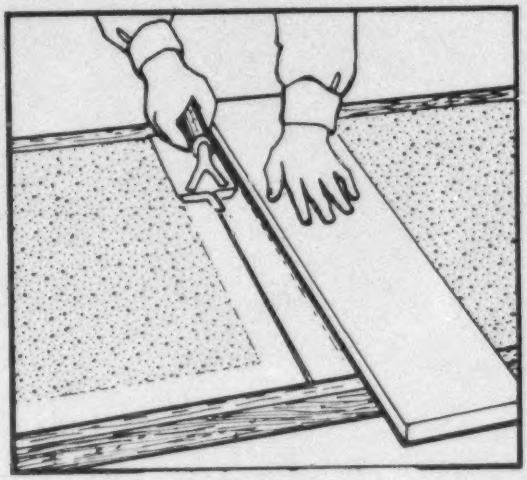


SEPARATING CONCRETE FROM FORM

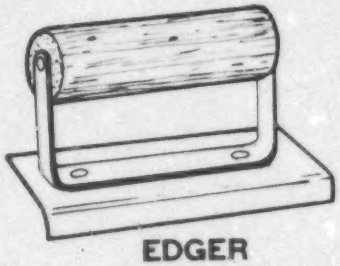
FINISHING CONCRETE



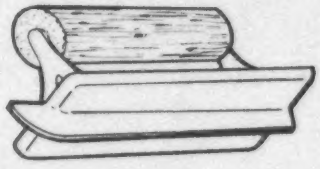
EDGING



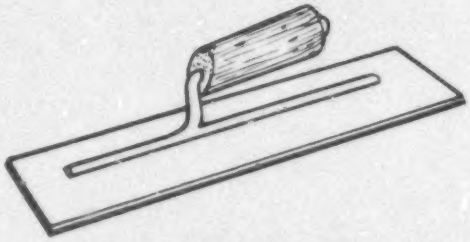
JOINTING



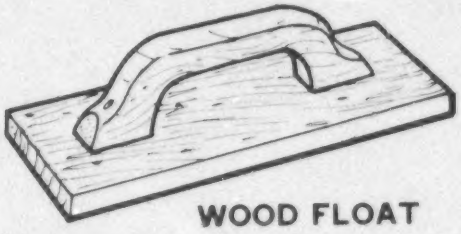
EDGER



JOINTER

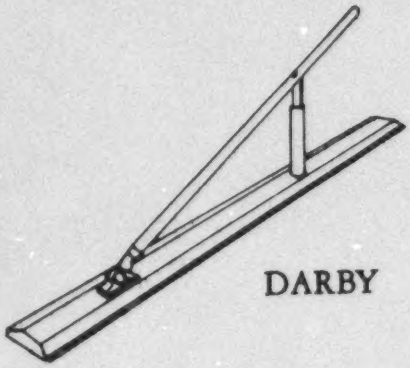


STEEL FINISHING TROWEL

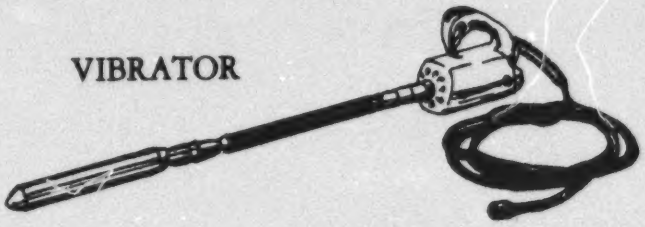


WOOD FLOAT

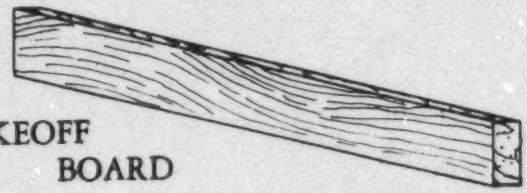
CONCRETE TOOLS



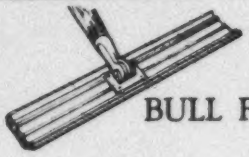
DARBY



VIBRATOR



STRIKEOFF BOARD



BULL FLOAT

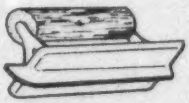
EDGER

METAL TROWEL

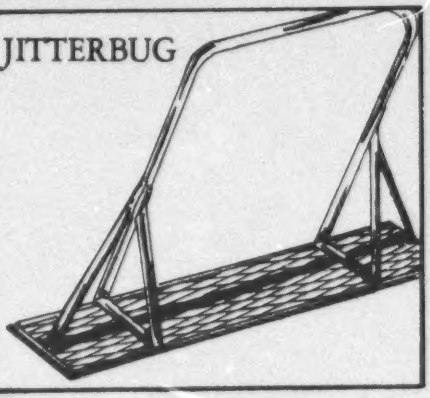
METAL FLOAT

WOOD FLOAT

POWER TROWEL

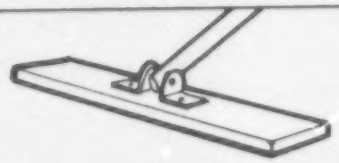
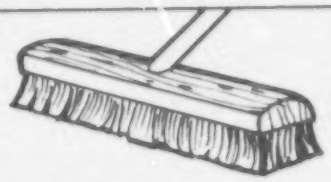


JOINTER OR GROOVER

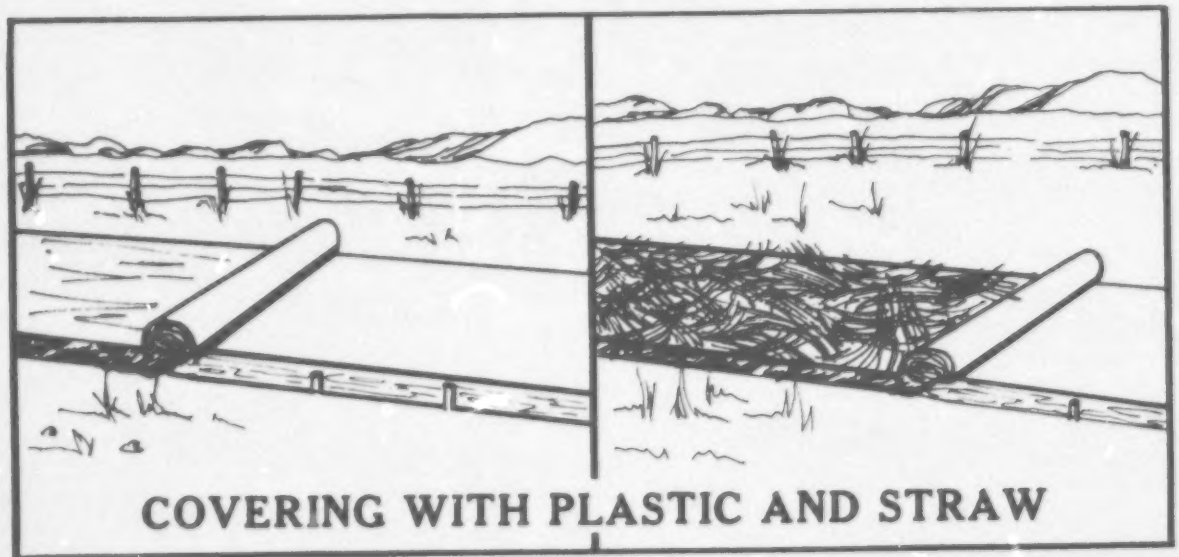


JITTERBUG

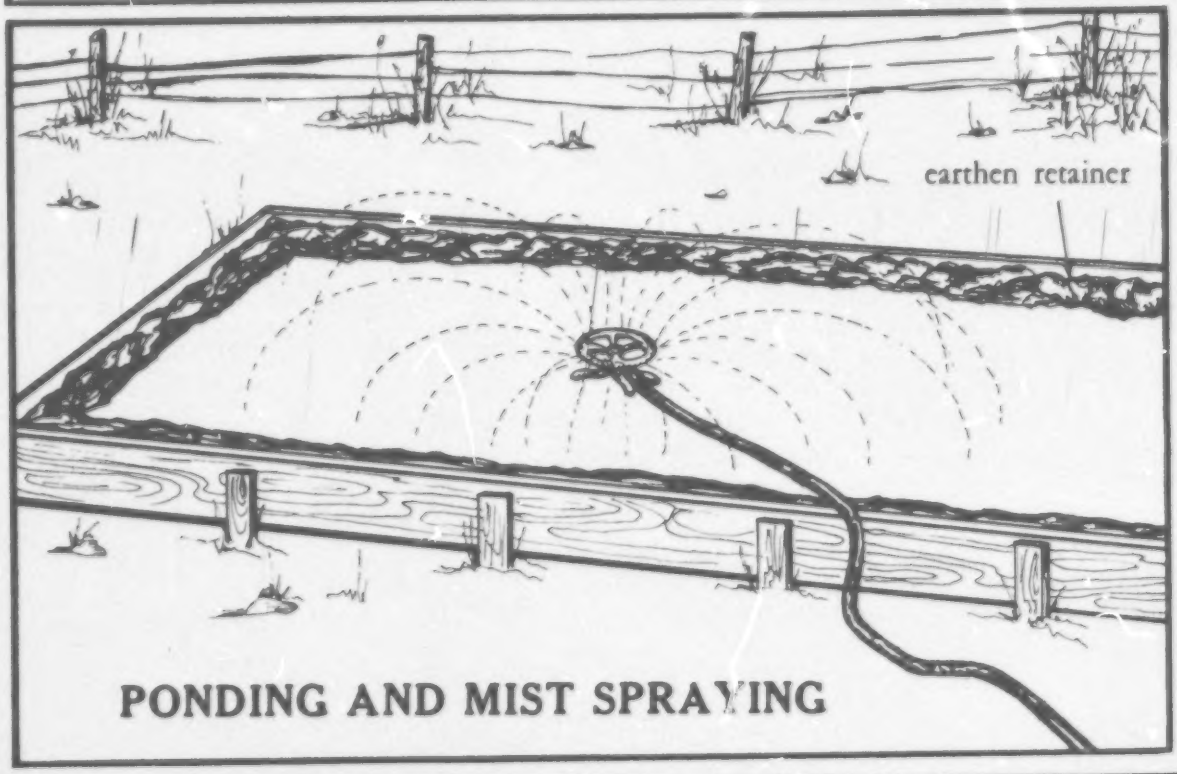
TYPES OF FINISH

SURFACE	USE	OBTAINED BY
GRITTY, NON-SLIPPING	WALKS, DAIRY BARN FLOORS, etc.	 USING WOOD FLOAT
COARSE, SCORED	DRIVEWAYS, FEEDING FLOORS, RAMPS	 USING STIFF BROOM
SMOOTH FINISH	TABLE TOPS, FEED TROUGHS	USING STEEL TROWEL
PEA GRAIN	PORCHES, WALKS, PATIOS	WASHING WITH WATER HOSE

CURING CONCRETE



COVERING WITH PLASTIC AND STRAW



PONDING AND MIST SPRAYING

CONSTRUCTION AND MAINTENANCE

Unit E: Concrete

Topic 4: Concrete Masonry

Suggested Procedure and Activities: A display of typical concrete masonry units may be helpful during the class discussion.

1. The Importance of Concrete Masonry

a. Many farm structures are built of concrete masonry materials for the following reasons:

Masonry structures are usually very durable. They resist severe weather conditions in most areas.

Less maintenance is required during the life of the building than is required for wood and some metal structures.

The masonry material does not corrode. This makes it adaptable to wet areas and areas that contain minerals in the air and soil that may affect metal. It is not affected by animal waste.

Masonry materials are firesafe, whereas most wood materials are not fire proof.

Most masonry structures are rodent and termite proof, that is, if the structure is constructed to eliminate damages by these pests.

Masonry buildings may be more economical to construct than steel or wood buildings.

b. Usually the term "concrete masonry" refers to concrete blocks or units made of a mixture of portland cement; sand, pebbles, cinders, or crushed rock, and water. However, buildings made of structural clay tile, brick, and stone are also considered as masonry structures.

2. Concrete Masonry Units or Blocks

Transparencies Nos. 1 and 2

Many different sizes and shapes of concrete masonry units are used in constructing buildings. The types and sizes of blocks are:

a. Stretcher (3 core) - 8 x 8 x 16 inches.

b. Stretcher (2 core) - 8 x 8 x 16 inches.

c. Corner - 8 x 8 x 16 inches.

d. Jamb or Joist - 8 x 8 x 16 inches.

e. Bull Nose Corner - 8 x 8 x 16 inches.

f. Pier or Double Corner - 8 x 8 x 16 inches.

g. Header - 8 x 8 x 16 inches

h. Partition - 4 x 8 16 inches.

i. Beam or Lintel - 8 x 8 x 16 inches.

j. Solid Top - 8 x 8 x 16 inches

k. Solid - 4 x 8 x 16 inches.

l. Sash - 8 x 8 x 16 inches.

The actual measurement of an 8 x 8 x 16 inch block is 7 5/8 x 7 5/8 x 15 5/8 inches. If the block is laid with a 3/8 inch mortar joint, the height area will be 8 inches and the length area 16 inches. All blocks of the same type are not the same size. For example, stretcher blocks may be 10 or 12 x 8 x 16 inches. It is usually a general practice to plan masonry buildings so that dimensions may be divided by 8 inches.

3. Foundations and Footings

A good foundation is an important part of any good building. The foundation cost is a fractional part of the cost of the entire building. The foundation consists of the bed (earth giving support), footing (the wide part of the foundation on the bed), and the wall (part of foundation resting on the footing).

The purpose of the foundation is to distribute the weight of a building and its contents over a given area so that the soil can support the entire weight of the structure.

The size of a footing depends upon the type of soil and weight of the structure and its contents. For example, soft clay has 1/4 the load carrying capacity of loose gravel or coarse sand. Some footing sizes are:

8 inch thick wall - 8 x 16 inch footing
10 inch thick wall - 10 x 20 inch footing
12 inch thick wall - 12 x 24 inch footing

Normally the footing is twice as wide as the foundation wall and as thick as the wall is wide.

Foundation walls may be constructed of cast-in-place concrete or concrete masonry. The cast-in-place walls may be poured at the same time the footing is poured or they may be poured separately. Concrete masonry walls are constructed by placing a bed of mortar on the footing to provide a good joint between the footing and block.

Most continuous foundations are set in the ground to prevent certain rodents from burrowing below them and to prevent rain from washing soil from beneath the foundation. Foundation walls may be capped if made of block to act as a termite barrier. The block cores are also filled with concrete to support beams.

4. Masonry Walls

Transparencies Nos. 3a, 3b, 3c, 4a, and 4b

a. Masonry walls should be constructed on dimensions that are divisible by 8 inches. Actually, this measurement must start with the foundation. If the masonry material is to be cut, a waste of materials and a waste of time will be involved in construction. Cut blocks distract from the appearance of a structure.

The wall should be constructed with full and half blocks. If the walls are built with 8 and 10 inch blocks it should not exceed 35 feet in height. Below grade walls are much stronger if built with 12 inch blocks.

b. Pilasters are columns that project about one third of their width to give the wall added support. If a building is longer than 2 1/2 times its width and does not have partitions that abut it, pilasters should be spaced as follows:

12 feet from center to center for an 8 inch block wall.

15 feet from center to center for a 10 inch block wall.

18 feet from center to center for a 12 inch block wall.

c. Lintels are reinforced beams used over openings (doors and windows). The lintel should be long enough to extend 8 inches on each side of the opening. The number and size of reinforcing bars used in lintels depends upon the number of feet clear span or the width of the opening below the lintel. For example, an opening up to 8 feet in width requires a lintel 7 5/8 inches high, 7 5/8 inches wide, and reinforced with two No. 3,3/8 inch round bars.

Steel lintels are used on several types of masonry walls. Reinforced tile is also used. Steel lintels are found on most brick walls, and tile lintels

are used on tile walls.

d. Anchor Bolts are used to anchor roofs to the walls. Bolts 1/2 inch in diameter by 18 inches long are inserted in block cores on four foot centers to anchor roofs. The bolts are fastened in the blocks by filling the cores with concrete. An 18 inch bolt will extend into the second layer of block. Wood plates are tied to tile walls by these anchor bolts.

Brick, rock, and tile veneer walls are tied to frame walls with metal ties; therefore, the roof is anchored to the wood frame.

e. Flashing prevents moisture from entering the masonry wall. It may be placed at the head or top of openings, top of foundation, and on window sills. It is necessary to use flashing on brick and tile walls where the masonry units are laid in a different direction. Usually, the bricks that form the sill on a window are laid so that the ends of the bricks show.

The most common metals used for flashing are:

Galvanized Sheet Metal - 26 gauge,

Hard Copper - 16 ounce, and

Aluminum.

f. Partitions may be constructed of the same material as the wall if the partition helps support joists or other loads. Non-supporting partitions may be constructed of masonry materials three to six inches in width. There are special blocks and tile for partitions.

Some masonry walls are bonded with the partition by the use of steel tie-rods spaced about three feet apart. Partitions that do not support joists may be tied to walls by heavy wire mesh. The mesh strip should be placed in every other joint at the time the wall is constructed.

5. The Preparation and Use of Mortar

Transparency No. 5

a. The purpose of mortar is to bond masonry units together to form strong walls and partitions. It is necessary that mortar have the strength to carry wall loads for the life of the structure. The solids in a mortar mixture are portland cement, hydrated lime, and sand. The strength of a mortar bond is affected by the following factors:

The quantity and type of cementing material.

The plasticity of the mortar and its workability.

The water holding capacity of the mortar.

The surface texture of the bedding area where the mortar is used.

The rate of suction of the masonry blocks or units.

The quality of workmanship when using mortar.

b. Mortar should be mixed for most jobs in a power mixer. It should be used within 2 1/2 hours after mixing. If evaporation causes the mortar to stiffen on the mortar board, it may be retempered by adding a small amount of water and remixing.

A ready mix of cement and hydrated lime is widely used because it eliminates the need for stockpiling extra material. Mortar sand and water are the other two ingredients needed for a complete mortar mix when masonry cement is used.

The proportions of materials by volume for mortar mixes are:

Cement	Hydrated Lime	Damp Mortar Sand
1 Portland Cement	1 to 1 1/4	4 to 6
1 Masonry Cement	- - - - - -	2 1/4 to 3
1 Masonry Cement plus 1 Portland Cement (heavy load construction)	- - - - - - -	4 1/2 to 6

Water is added until the mixture becomes plastic and works well with the trowel.

About 100 blocks 8 x 8 x 16 inches may be laid with one sack of masonry cement and three parts of sand. If the exposed area of a block is 7 5/8 by 15 5/8 inches and the mortar joint is 3/8 inch, the quantity of block and mortar to use for 100 square feet of wall area is:

Thickness of Wall (Inches)	Number of Blocks	Cu. Ft. of Mortar
8	112	8.5
12	112	8.5

Transparencies Nos. 6, 7, 8, and 9

6. Laying Concrete Blocks

a. Place concrete blocks on a platform or pallets to protect them from ground moisture. Cover blocks to protect them from rain. Blocks must remain dry before and after laying.

b. Locate the corners and string out the first layer of blocks to check the layout. The blocks may be aligned by using a chalked snap-line.

c. Remove the line of blocks and place a full mortar bed on the foundation wall. Position the corner block first. Apply mortar to the vertical joints before setting them in place. Apply mortar to the thicker surface of the block.

d. After the first few blocks are laid, check the alignment and grade by using a mason's level as a straight edge and level. Use the trowel to tap the blocks in place. Lay the first course with care. If the first course is leveled and plumbed, succeeding courses will be easier to lay.

e. After the first course is laid, apply mortar on each side of the (upper surface) laid block. Then apply mortar to the vertical edges of the block to be laid. Mortar may also be applied to the vertical face of the laid block.

f. Lay the corners first, making them four or five courses higher than the center of the wall. Check with a mason's level for alignment, for being plumb, and for being level. The height of a course should be checked with a course pole which is graduated in 8 inch markings. The blocks may be checked for alignment by placing the level at a diagonal position from the corner.

g. Lay blocks between corners by first stretching a line so that the top of the course to be laid will touch the line. Blocks are leveled and aligned by tapping them with the trowel handle as they are set in place. The face of blocks can be checked with the level. Remove excess mortar and rework it on the mortar board before using the second time.

h. Close the course by buttering all four vertical edges of the blocks and lower the closure block into place. If an open space appears, remove the block and repeat the procedure.

i. Tool the mortar joints as soon as the mortar becomes thumb-print hard. Tooling forces the mortar against the block edges and produces uniform clean lines. The tooling tool should be about 24 inches long, turned up at one end, and should have a handle in the center. A 5/8 inch round bar will

produce a concave joint, and a 1/2 inch square bar will produce a V-shaped joint. The wall should be rubbed with a burlap bag to remove mortar burrs.

j. Wall control joints may be made after the mortar is quite stiff or during the time the wall is being constructed. The methods of forming a control joint are:

Remove the mortar from a depth of about 3/4 inch and force calking compound into the vertical joint. Use control joint blocks that are made full and half length at the time the course is being laid. Jamb block may be used as wall control block if the joint is reinforced by a Z-tiebar.

k. Intersecting bearing walls terminate at the face of the main wall with a control joint at that point. Use tie bars (metal lath 1/4 inch thick, 1 1/2 inch wide and 28 inches long, with 2 inch right angle ends). The ends of the lath are imbedded in concrete on the horizontal joints.

l. Tie nonbearing wall to main wall by using 1/4 inch mesh galvanized hardware cloth in the horizontal joints of both walls. The hardware cloth is usually tied into the main wall first. Where the two walls meet, the mortar is chipped out 3/4 of an inch and the vertical joints are filled with calking.

7. Laying A Cavity Wall

Transparency No. 10

a. Cavity walls are actually two walls that are constructed on a single foundation. Such walls may be constructed of partition masonry units that are 3 5/8 x 7 5/8 x 15 5/8 inches in size. The following procedure is used to construct the walls.

b. The masonry units are laid in the same manner as laying standard wall blocks. An air space is left between the walls, and they are tied together across the air space by a No. 6 gauge wire. The wire is bent in the form of a rectangle, and it is spaced every 16 inches vertically and 32 inches horizontally.

c. Weepholes may be made at the bottom of the walls by placing a piece of rubber hose in the horizontal joint and removing it after the mortar has hardened. Approved metal flashing is placed on the first course masonry unit and on the foundation wall (metal flashing bent in the form of a slanting double L - $\int$) to free the cavity of moisture.

d. The cavity is protected from mortar droppings while constructing the walls by placing a board across the opening. The board is pulled from between the walls and cleaned.

e. Four-inch clay tile is commonly used to construct cavity walls. Tile is lighter and easier handled than concrete blocks for this type of work. Block walls may cost less to construct than tile walls.

8. Veneered Walls

Transparency No. 11

a. One of the most common types of masonry wall for homes is brick veneer. There are also homes that have rock veneered walls. These walls are supported by a masonry foundation and a frame wall. The frame wall is usually made of wood studs, pressed board, or wood outside sheathing covered with building paper and an interior wall covering.

b. The brick or stone is tied to the wall by metal ties that are nailed to the wall and extended into the mortar on the upper horizontal side of the brick or stone. These ties should be spaced not more than 2 feet apart, and there should be a tie for each two square feet of wall.

9. Laying Brick, Tile, and Stone

The general procedure used to lay concrete block is used to lay brick, stone, and tile. But certain practices are followed when laying brick and other masonry units that are not followed when laying concrete blocks.

a. Laying brick - Brick should be soaked with water several hours before they are laid. The outside should be dry and the inside moist at the time they are laid.

A thick mortar bed is spread before mortar is placed on the end of the brick.

As the brick is pushed into place, excess mortar is squeezed from the joints and cut off. Mortar joints range from 1/4 to 1/2 inch thick.

The joints are tooled to force the mortar against the brick and make the joints appear smooth. Proper tooled joints are more weather resistant than rough joints.

Transparency No. 11

The four most common types of brick are:

Standard - 2 2/3 x 4 x 8 inches
Norman - 2 2/3 x 4 x 8 inches
Roman - 2 x 4 x 8 inches
SCR - 2 2/3 x 6 x 8 inches

Brick classes are: building, facing, and glazed facing.

b. Laying Stone - Stone should be soaked and the outer surface allowed to dry before it is laid.

A full mortar bed is necessary for laying stone properly. About 3/4 of an inch of mortar is moved before the mortar hardens. The raked out joints are moistened and refilled (flush or concave) with mortar.

Rubble stone masonry (from roughly dressed or field stones) is considered most appropriate for farm buildings. Ashlar stone masonry (from sawed or dressed stones) is not commonly used for farm structures.

c. Laying Tile - The first course of tile is laid in a full bed of mortar in the same manner as concrete block. Facing tile stretcher units usually are available either with vertical or horizontal cells.

The horizontal-cell tile that is more than four inches wide is laid in a divided mortar bed (two rows of mortar along the inner and outer edges). One end of the tile is buttered with mortar before it is placed in the bed.

The tile mortar joint should be about 1/2 inch thick. The joint should be tooled with a round bar.

Three types of tile are structional facing, backup, and grain bin or silo. Structional facing tile may be glazed or unglazed and used for interior or exterior walls. Backup tile is used as a support or backup wall for brick or tile. It may also be used as a base for planters. Grain bin or silo tile is used for the construction of circular bins.

Transparencies Nos. 12 and 13

10. General Information on Concrete Masonry

a. Concrete block may be used as backup for brick, stone, and tile. The first course may be a header or stretcher course. The ends of the brick will show in a header course, whereas the sides will show in a stretcher course. One stretcher course on the inside of the bricks should be parged (mortar spread over sides of bricks) before the block is fitted into place.

b. Cutting concrete masonry units may be done with a chisel and mason hammer or a masonry saw. If a chisel is used, the block should be scored on both sides before the cut is made. If a saw is used, the masonry unit should be dry.

c. Any masonry structure should be protected from rain; therefore, tarpaulins or plastic covers should be used for covering structures with moist or soft mortar.

d. Cleaning and patching masonry structures is a final step to completing the job. The steps that may be followed are:

Fill all nail or line pin holes with fresh mortar. Avoid smearing fresh mortar in masonry units. Mortar droppings that stick to the units (blocks, bricks, and tile) should be allowed to dry before removing. A trowel and a brush are good hand tools to aid in removing mortar patches.

11. Some Masonry Tools and Cleaning and Patching Masonry Structures

Transparency No. 14

Level or Plumb Rule - These are available in either wood or metal and in lengths of 36 to 48 inches. The better quality levels have two level glasses at the center and plumb glasses near each end.

Trowels - The most used tool in masonry work is the trowel. Attention is directed to the differences in the shapes of the trowels in the above illustration. Better quality trowels are forged from a good grade of steel and hand ground to the proper shape, taper, and balance. Trowels of different lengths and widths may be purchased.

Jointers - The mortar joints are finished with these tools. A 5/8 inch rod 24 inches long may also be used to finish the joints of concrete masonry units. Those in the illustration are made by casting or forging.

Brick Set - This is a chisel like tool used to cut brick and concrete masonry units. A brick layer's hammer is used to strike the set.

Brick Hammer - The head is square and sharp and is used for splitting brick. A cut line is made around the brick by lightly tapping the brick with the head of the hammer. After the line is completed, a heavy blow is given to the center of the brick. Practice is required to get a clean cut. The blade of the hammer is used to trim the rough areas.

Corner Blocks - These are used to hold the string in place and may be hand made or purchased.

Electric Portable Saw - Electric saws are particularly useful when a large number of units need to be cut. Stationary masonry saws are also available.

Cleaning and Patching Masonry Structures - The last step in the construction of a masonry structure is cleaning and patching. The mason should be careful not to smear or throw mortar on blocks, brick, stone or tile. Should these become smeared with mortar, they should be allowed to dry before cleaning them. A trowel and steel brush are used to remove the dried mortar.

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1. Ashby, Wallace and Others, Modern Farm Buildings, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1959.

2. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, IL, 1967.

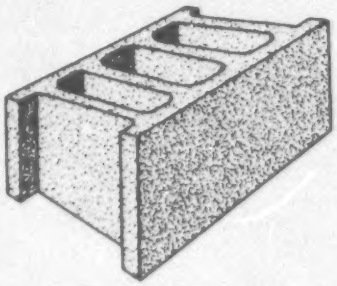
3. Wakeman, T. J., Modern Agricultural Mechanics, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1977.

4. "Recommended Practices for Laying Concrete Block", Portland Cement Association, Skokie, IL 1963.

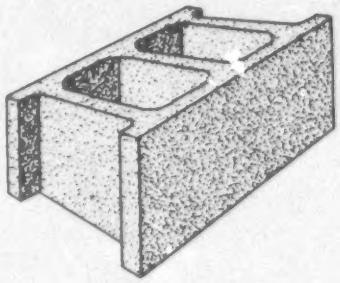
5. "Recommended Practices for Building with Concrete Masonry", Vocational Agriculture Service, University of Illinois, Urbana, IL, 1972.

6. "Concrete Improvements for Farm and Ranch", Portland Cement Association, Chicago, IL, 1963.

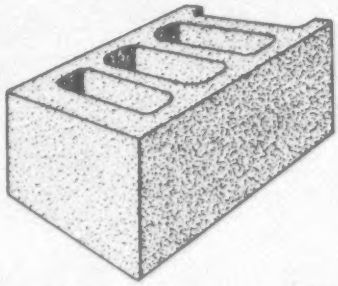
MASONRY BLOCKS



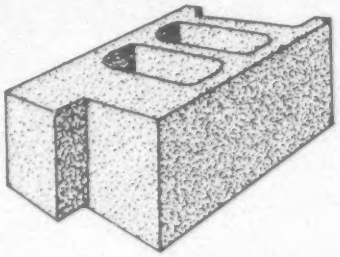
a. CORE STRETCHER



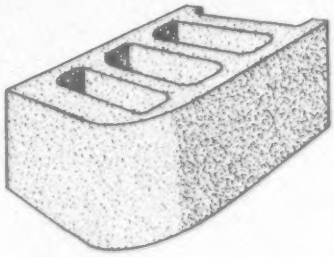
b. CORE STRETCHER



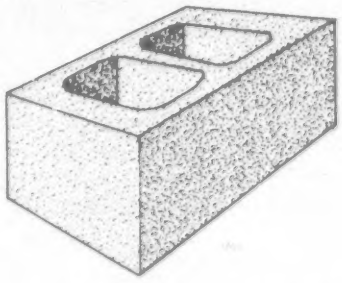
c. CORNER



d. JOIST or JAMB

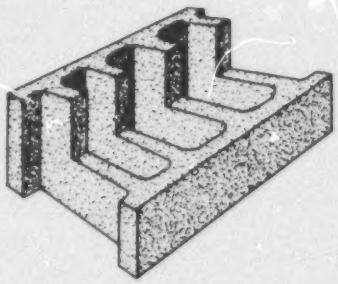


e. BULLNOSE CORNER

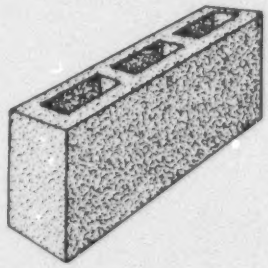


f. DOUBLE CORNER

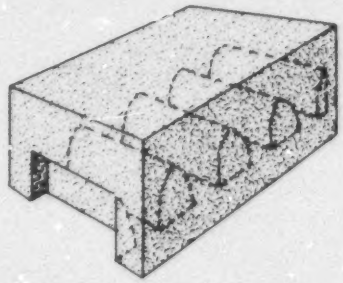
MASONRY BLOCKS



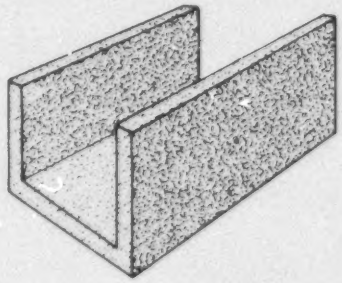
g. FULL-CUT HEADER



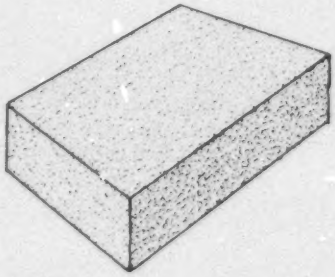
h. PARTITION



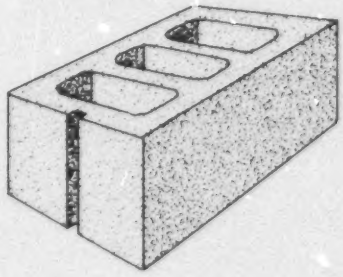
i. SOLID TOP



j. BEAM or LINTEL

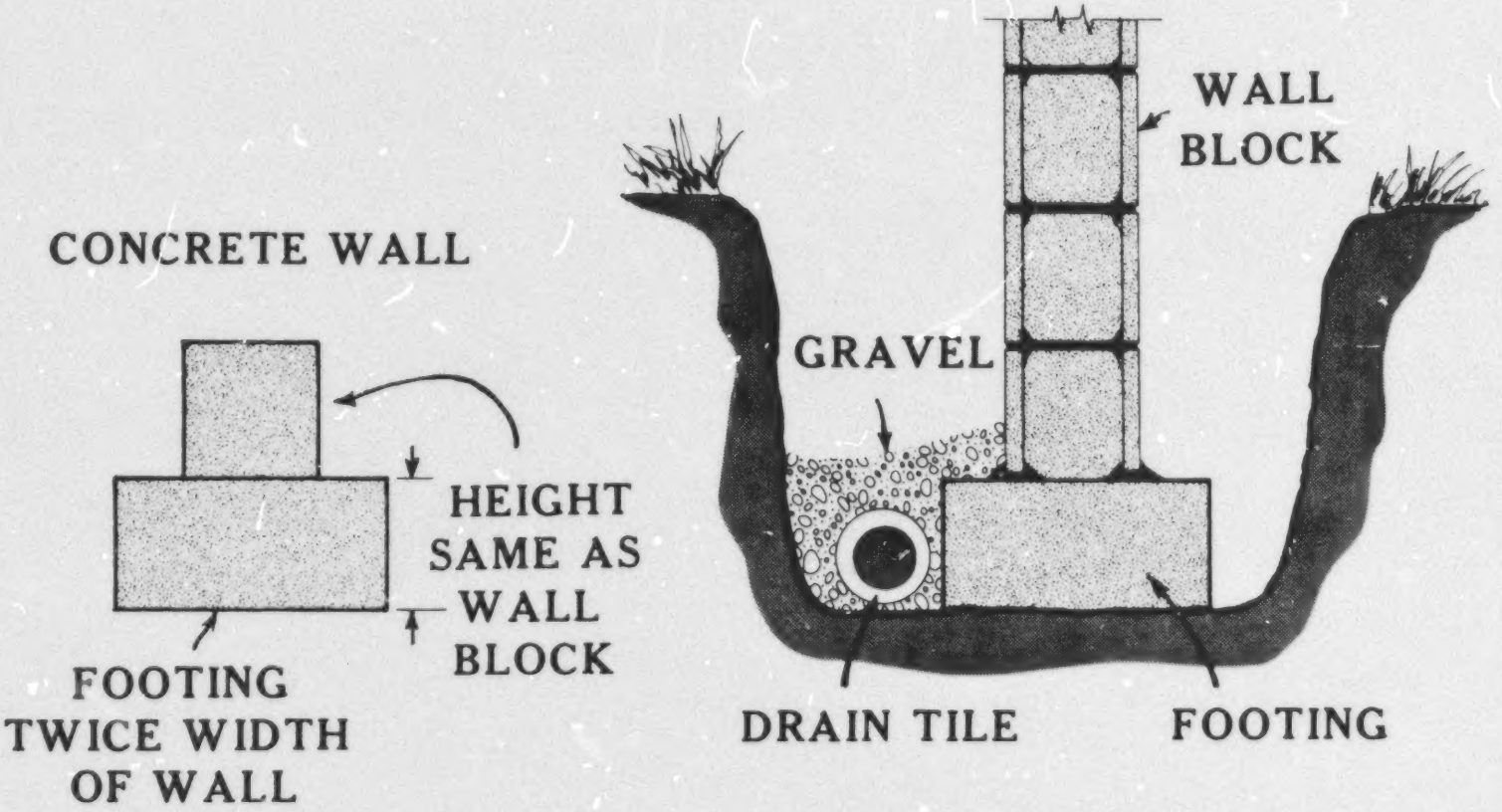


k. SOLID



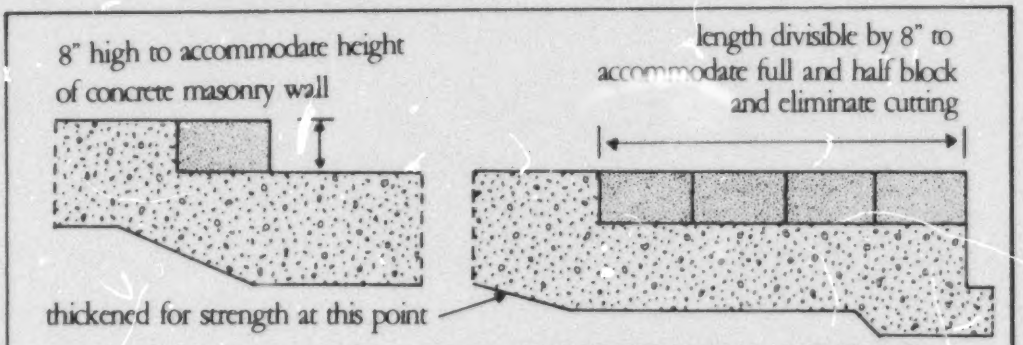
l. SASH

FOUNDATIONS & WALLS

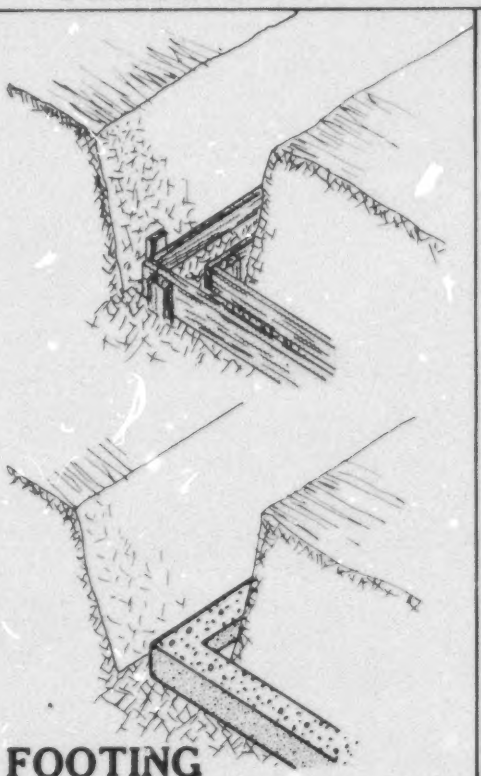


TWO TYPES OF FOUNDATIONS

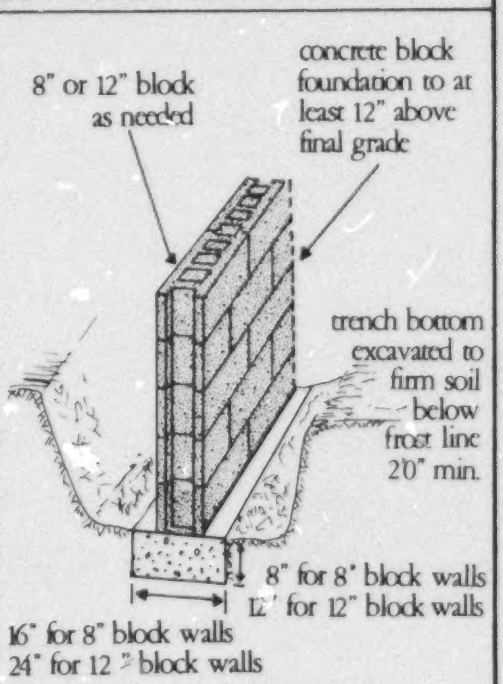
FOOTINGS FOR MASONRY WALLS


8" high to accommodate height of concrete masonry wall
length divisible by 8" to accommodate full and half block and eliminate cutting
thickened for strength at this point

PLACING FOOTING ON UNEVEN AREAS

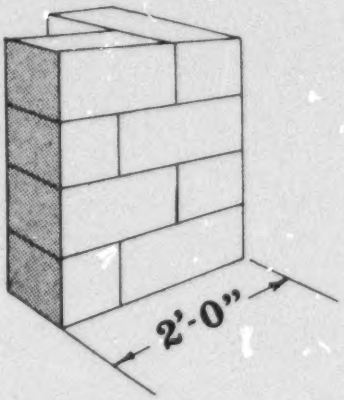


FOOTING TRENCH IS FLAT

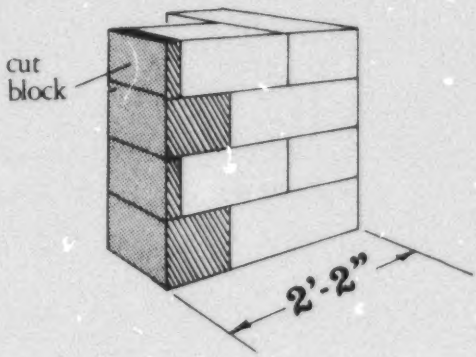

8" or 12" block as needed
concrete block foundation to at least 12" above final grade
trench bottom excavated to firm soil below frost line 20" min.
8" for 8" block walls
12" for 12" block walls
16" for 8" block walls
24" for 12" block walls

FOOTING IS TWICE AS WIDE AS THE MASONRY

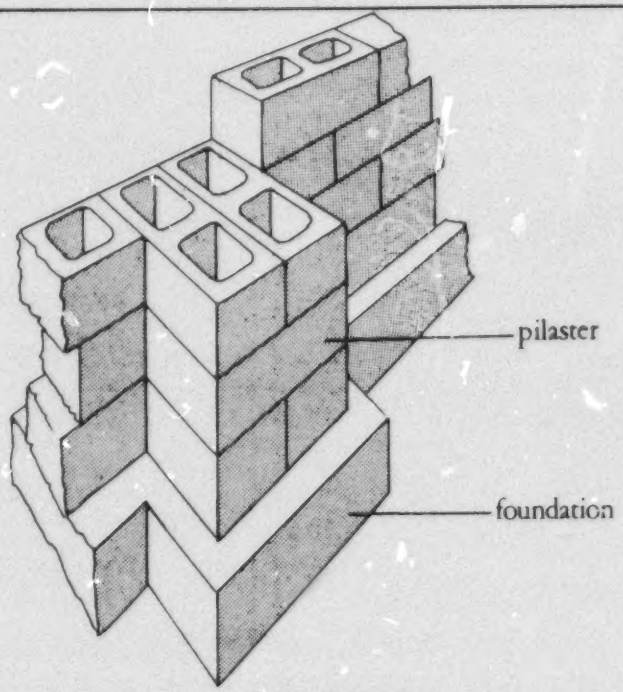
FOUNDATIONS AND WALLS



CORRECT WALL MEASUREMENT

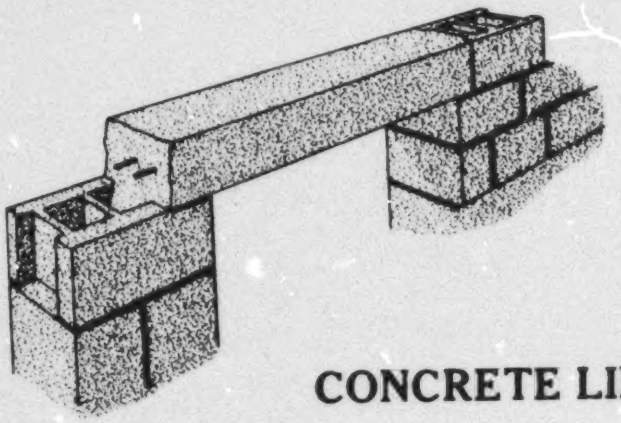


INCORRECT WALL MEASUREMENT

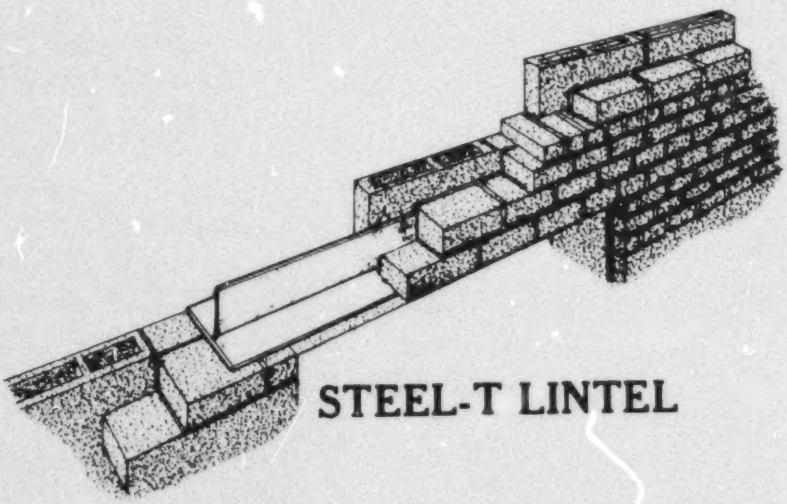


WALL SECTION

LINTELS

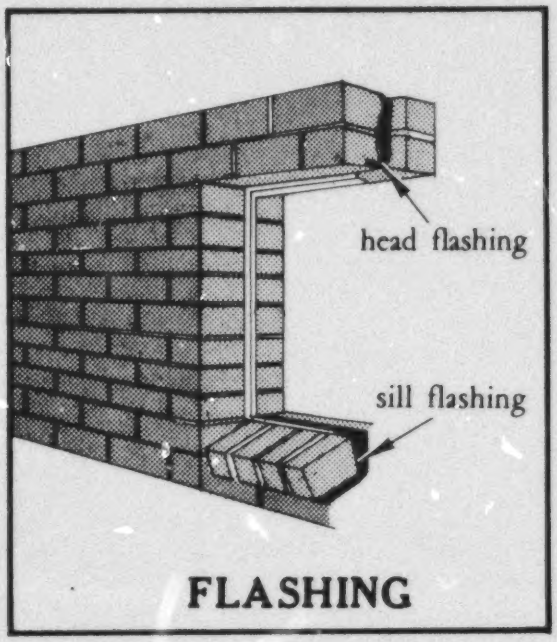


CONCRETE LINTEL

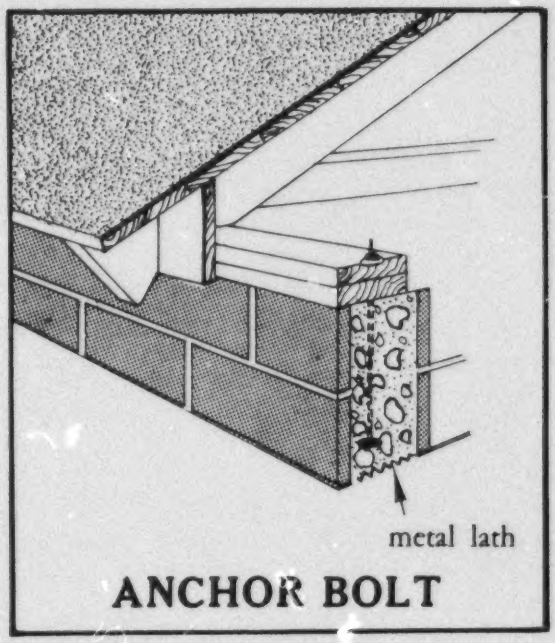


STEEL-T LINTEL

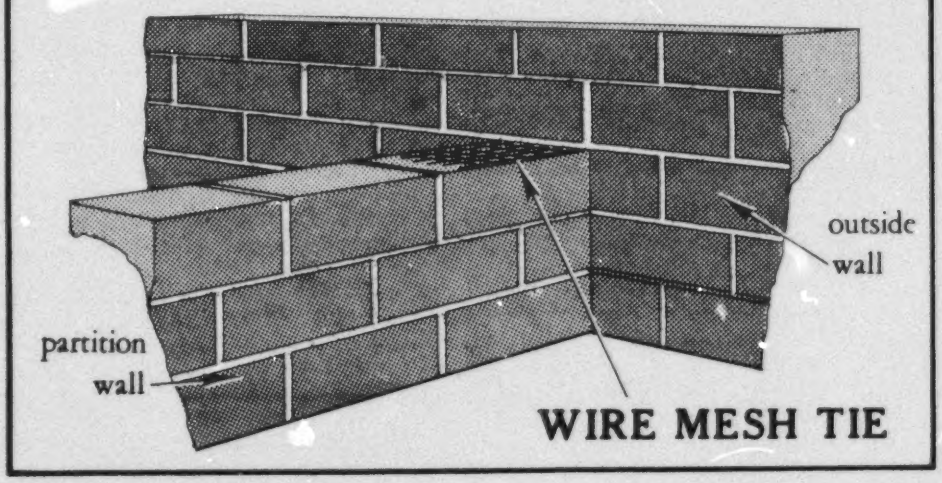
ANCHOR BOLT AND FLASHING



FLASHING



ANCHOR BOLT



WIRE MESH TIE

CONCRETE MATERIALS CALCULATION

RECOMMENDED MORTAR MIXES

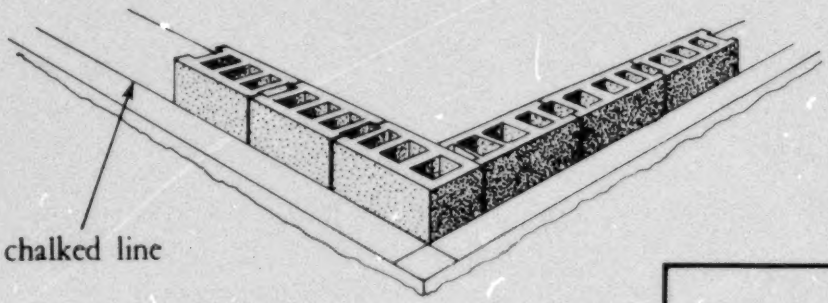
(Proportions by Volume)

Type of Service	Cement	Hydrated Lime	Mortar Sand in Damp, Loose Condition
For ordinary Service; Walls above ground	1-masonry cement or 1-portland cement	- - - - - 1 to 1 1/4	2 to 3 4 to 6
Heavy Loads, violent winds, severe frost action; Isolated piers	1-masonry cement plus 1-portland cement or 1-portland cement	- - - - - 0 to 1/4	4 to 6 2 to 3

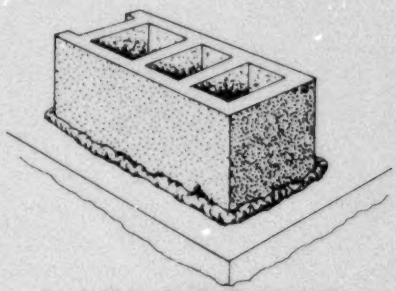
QUANTITIES OF MATERIALS FOR CONCRETE MASONRY WALLS

Size	For 100 Sq. Ft. of Wall: No. Units	Cu. Ft. Mortar	Cu. Ft. Mortar for 100 Units
3 5/8 x 7 5/8 x 15 5/8	112.5	2.6	2.3
5 5/8 x 7 5/8 x 15 5/8	112.5	2.6	
7 5/8 x 7 5/8 x 15 5/8	112.5	2.6	
11 5/8 x 7 5/8 x 15 5/8	112.5	2.6	

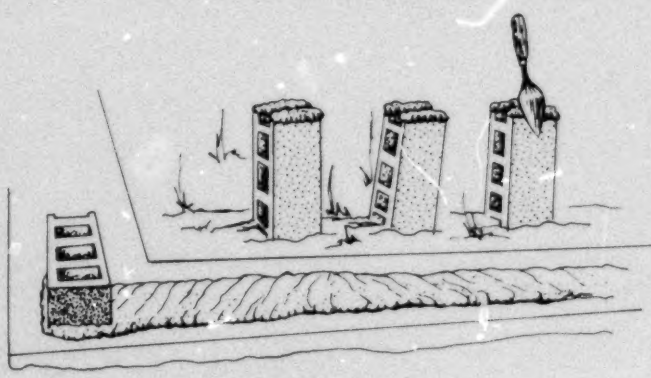
LAYING MASONRY UNITS



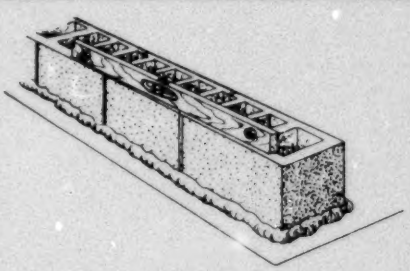
ALIGNING FIRST COURSE



LAY CORNER BLOCK

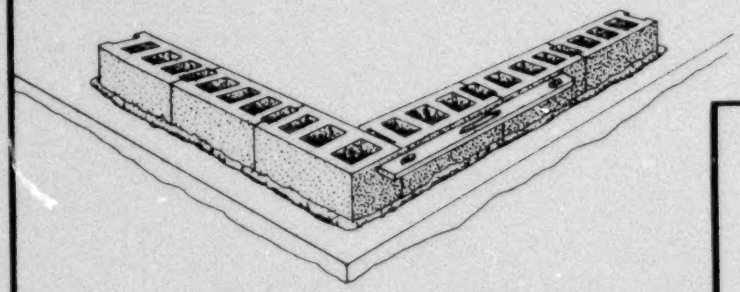


APPLY MORTAR TO FOUNDATION AND BLOCKS

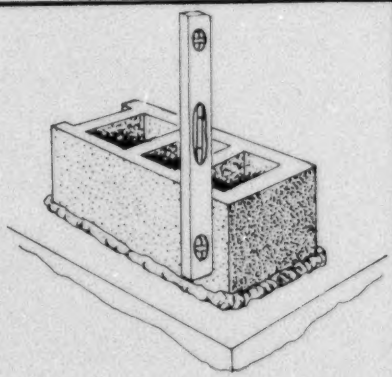


LEVEL BLOCKS

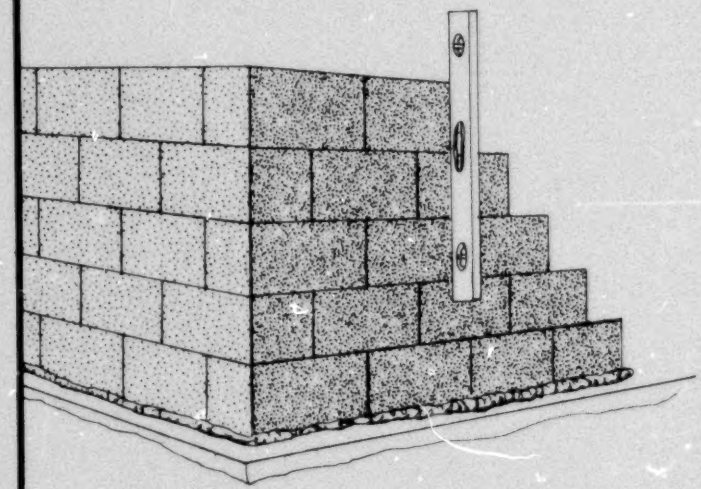
LAYING MASONRY UNITS



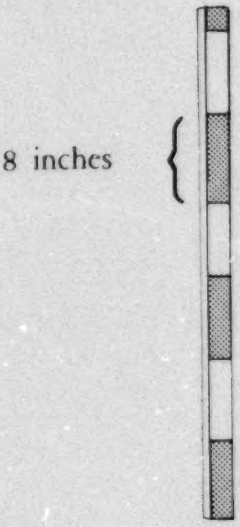
ALIGN BLOCKS WITH LEVEL



PLUMB FIRST COURSE

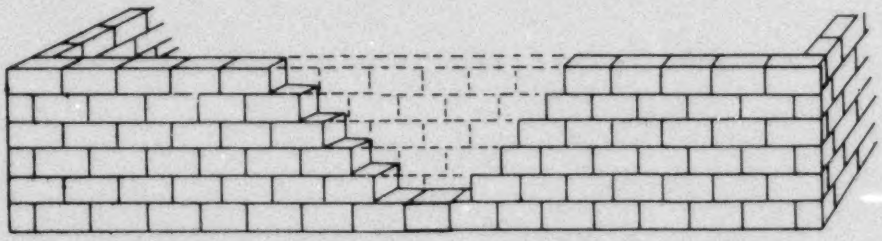


CHECK PLANE OF WALL

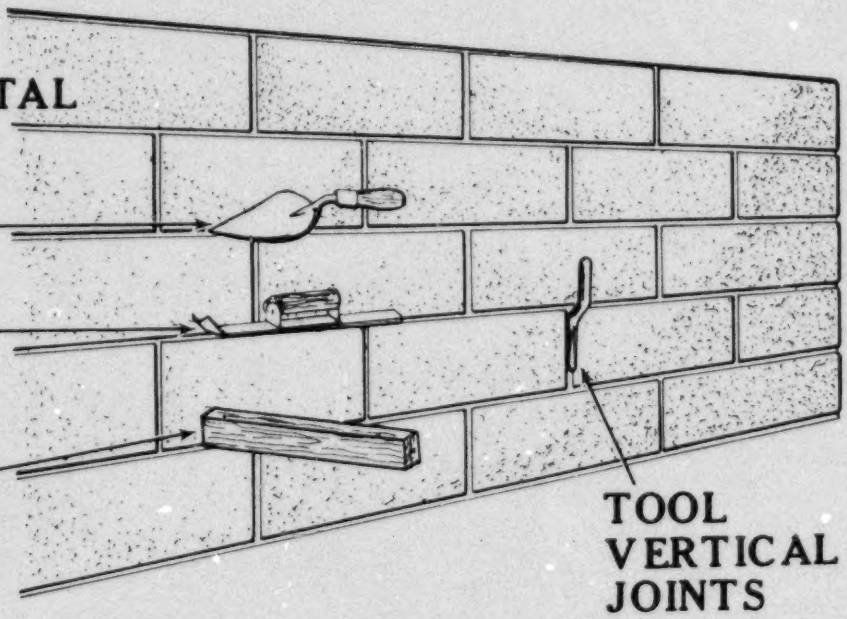


COURSE POLE

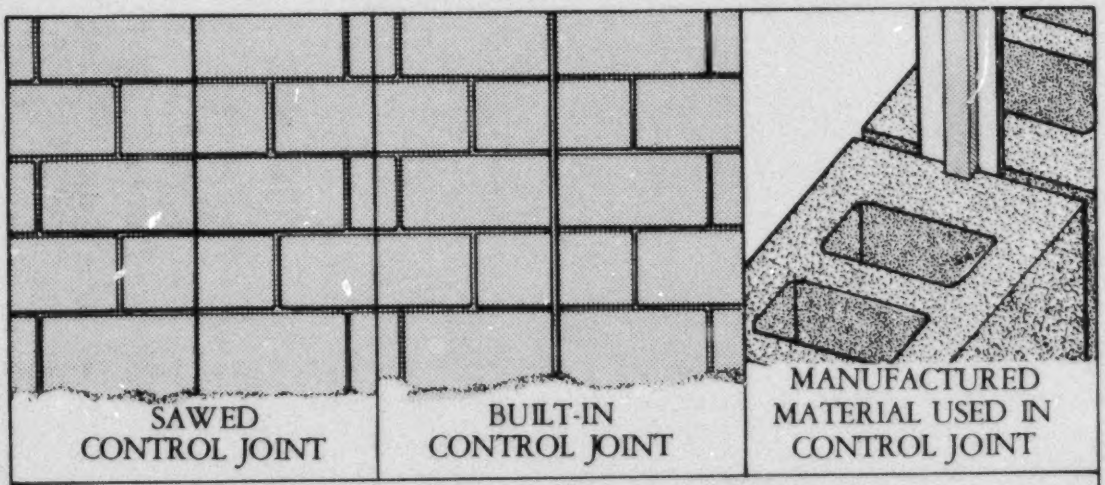
LAYING MASONRY UNITS

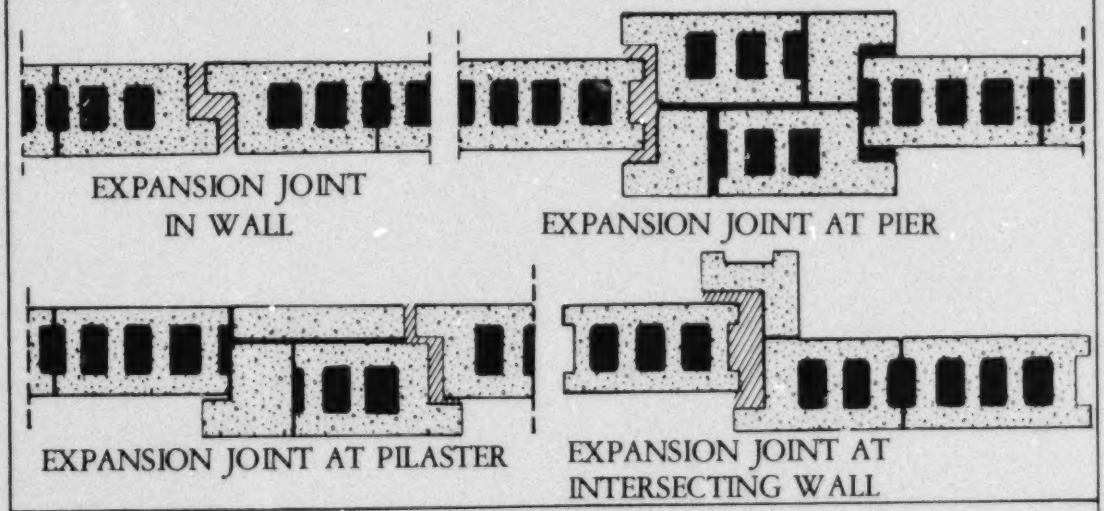


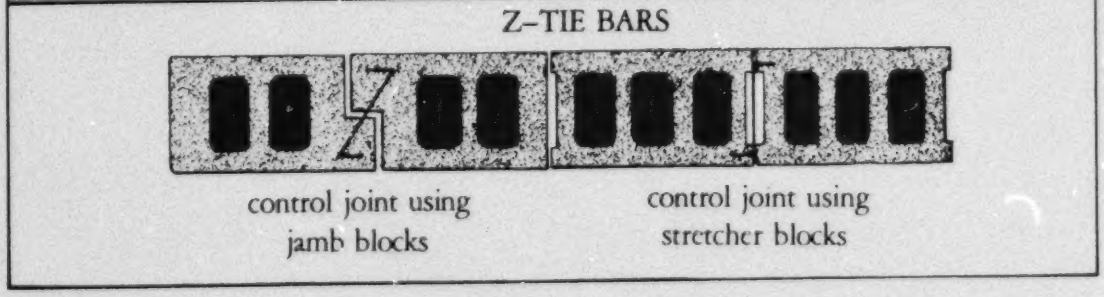
CLOSE CENTER BETWEEN CORNERS



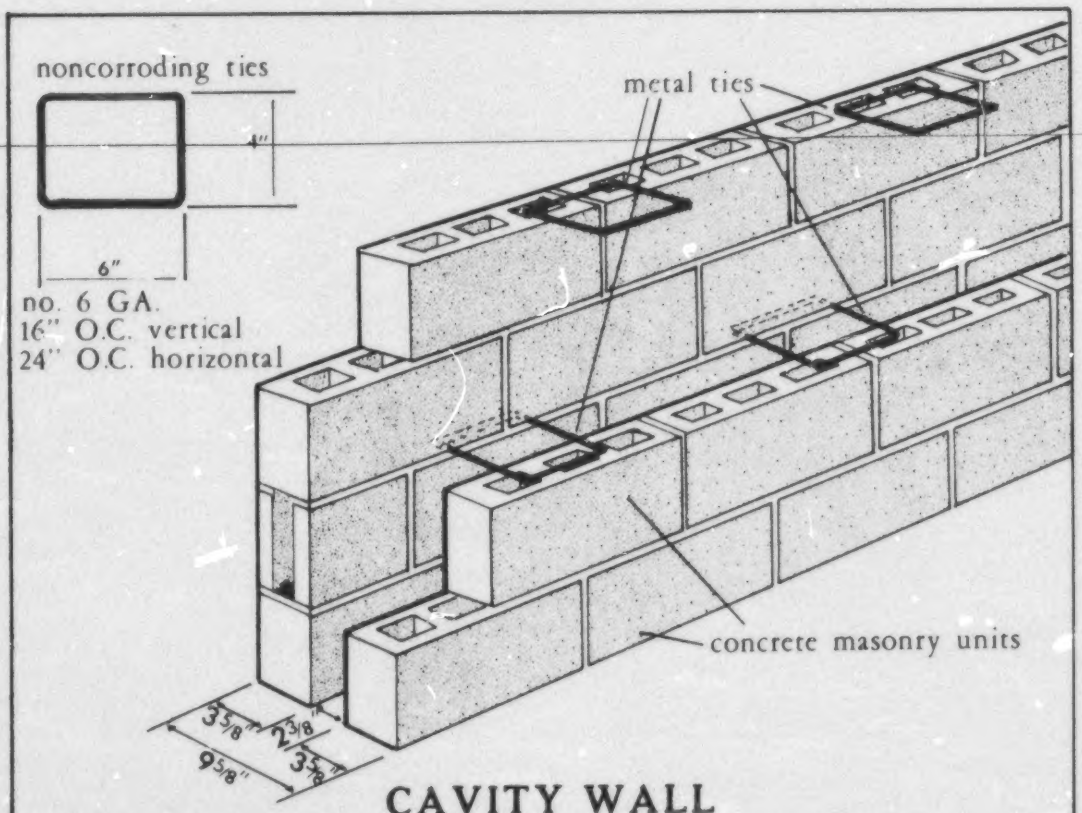
CONTROL JOINTS



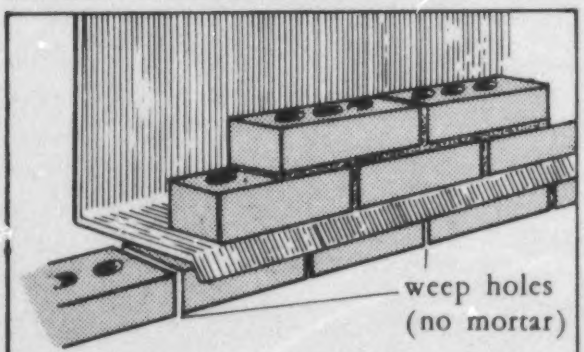




BUILDING BLOCKS



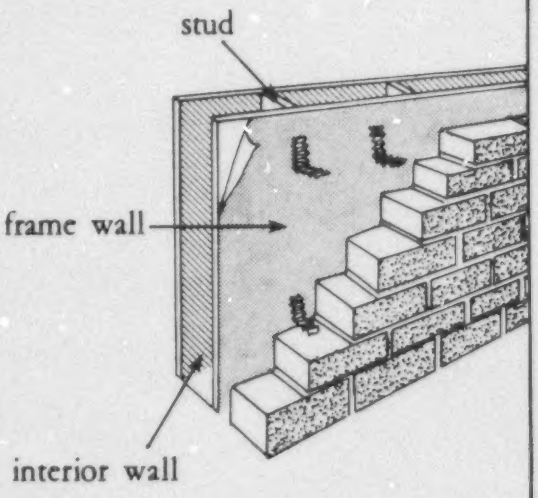
CAVITY WALL



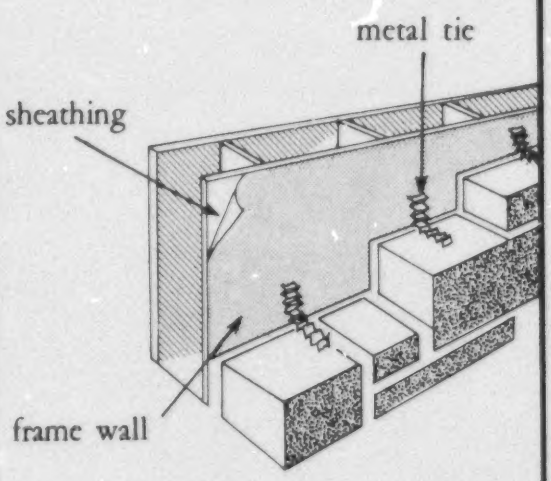
METAL FLASHING

MORTAR DROPPING BOARD

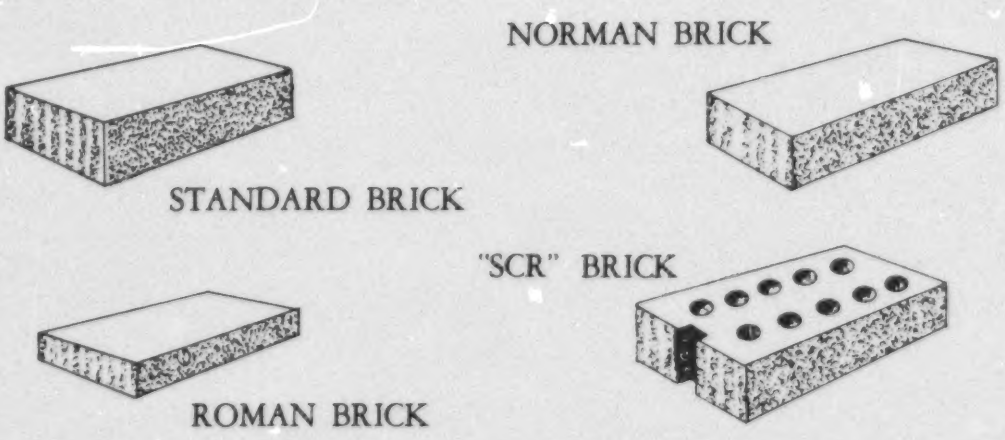
TYING VENEER WALL



BRICK VENEER



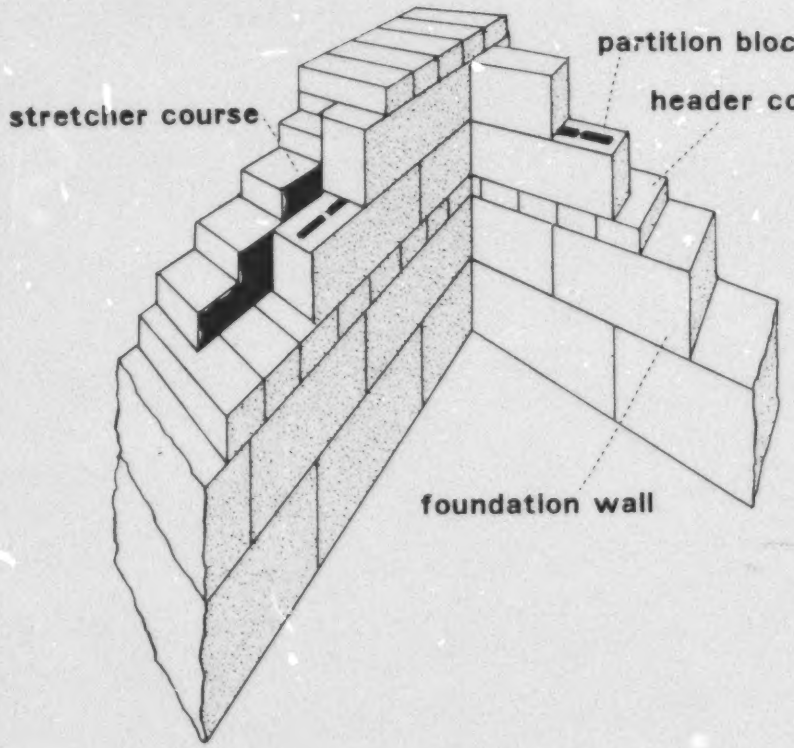
ROCK VENEER

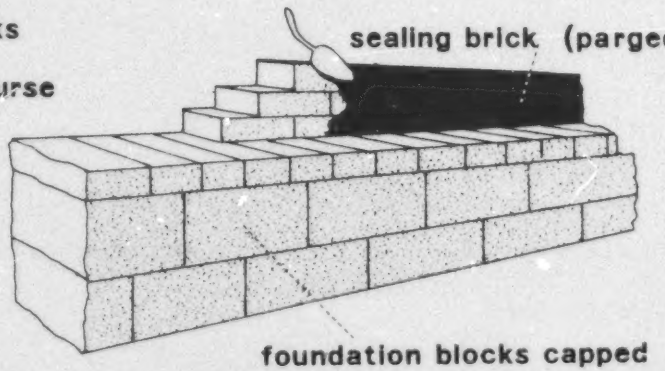


SOME TYPES OF BRICK

LAYING MASONRY UNITS

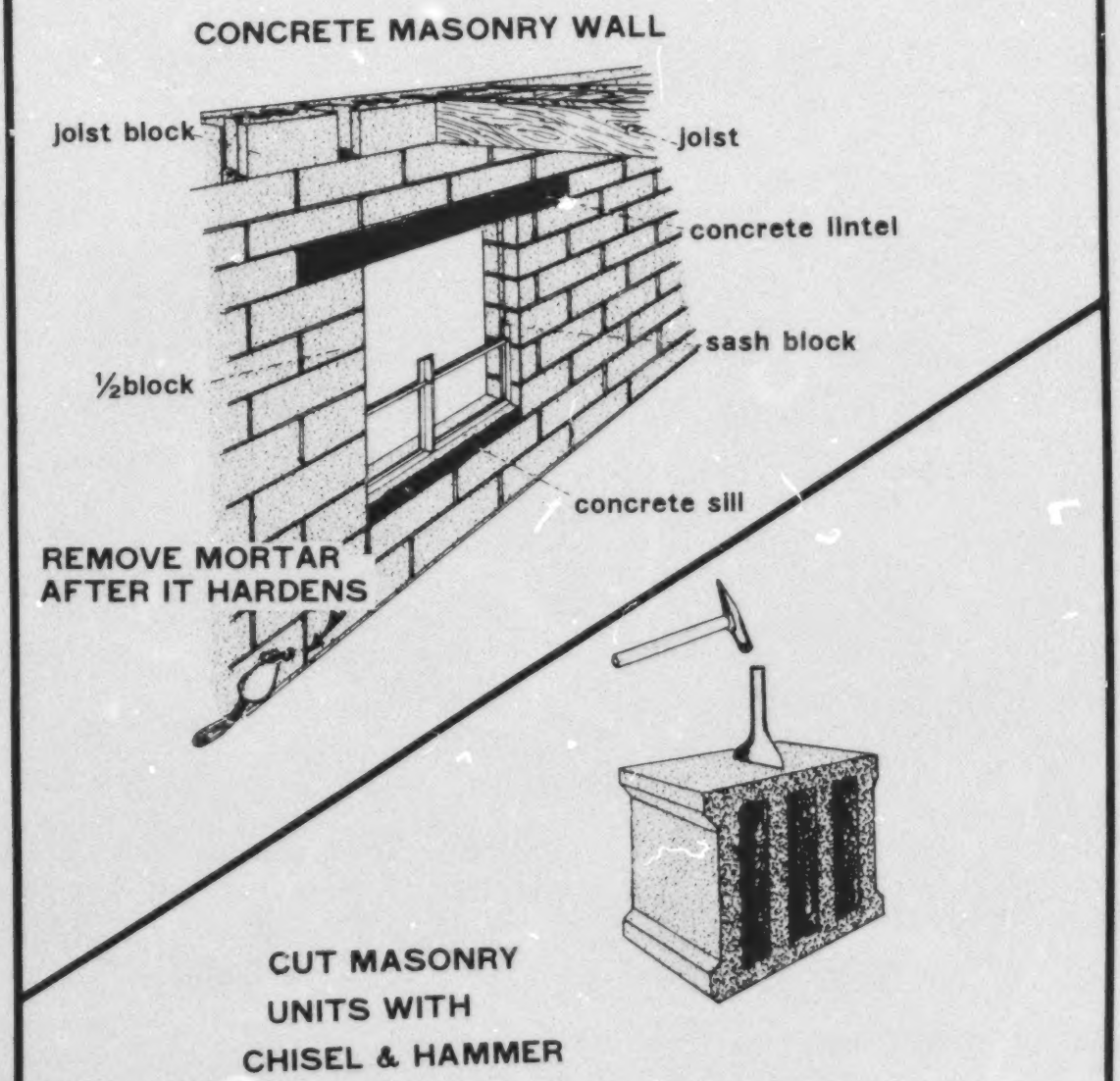
MASONRY WALL WITH BRICK





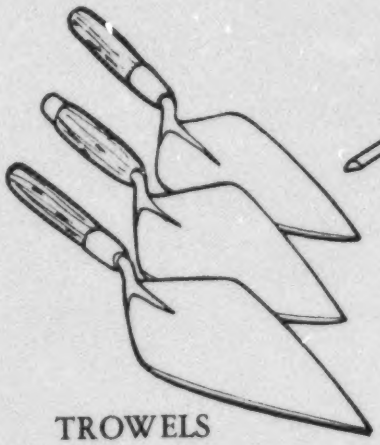
SEAL INSIDE BRICK AND CHECK ALIGNMENT

LAYING MASONRY UNITS

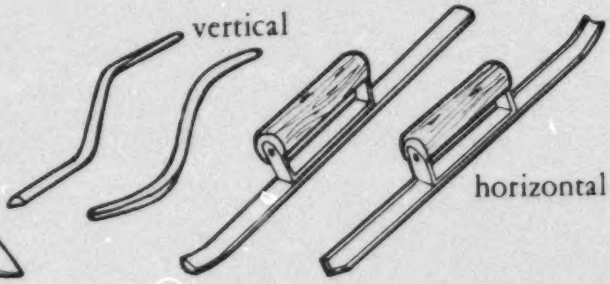


MASONRY TOOLS

LEVEL OR PLUMB RULE

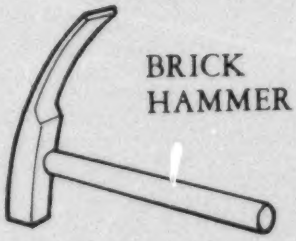


TROWELS

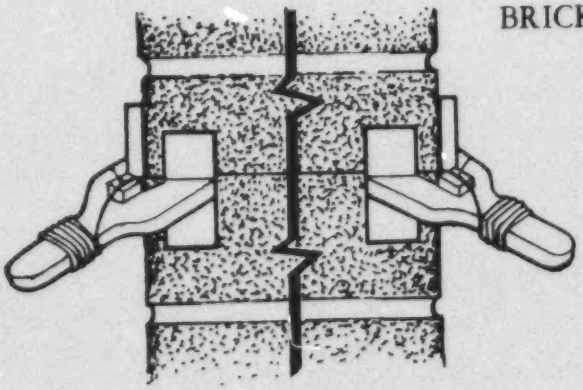


JOINTERS

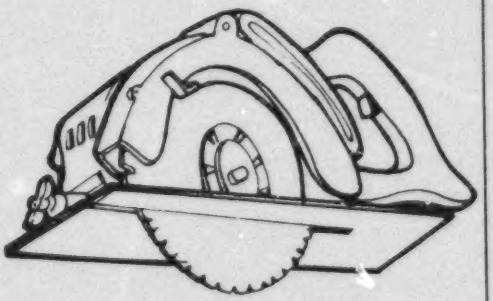
BRICK SET



BRICK HAMMER



CORNER BLOCKS



ELECTRIC PORTABLE SAW

HOT METAL WORK

Unit A: Oxyacetylene Welding and Cutting

Topic 1: Safety Precautions and Procedures for Welding and Cutting

Suggested Procedures and Activities: If the oxyacetylene unit is mobile, move it into the class room and use it as a teaching aid during the class discussion. If the unit is immobile, such equipment as cutting and welding tips, spark-lighter, cutting attachment, welding torch, and goggles could be used as teaching aids.

1. Introduction

Oxyacetylene cutting is a process used to separate metal by heating it to a kindling temperature (burning temperature) between 1400 and 1800 degrees F., then oxidizing and blowing the metal from the cut with a stream of oxygen.

Oxyacetylene welding is the joining of two pieces of metal together by heating them to the melting point provided by combustion of gas mixture, oxygen and acetylene.

The oxyacetylene flame is used to weld iron, steel, brass, copper, aluminum, bronze, cast iron, and special alloys. It is also used extensively for cutting metal, annealing, and hardening.

The flame reaches a temperature of about 6300 degrees fahrenheit. The temperature may be adjusted to fuse or cut (melt) any commercial metal.

An oxyacetylene welding and cutting outfit is considered a very useful tool for the modern farm and ranch. It is used to build equipment and do repair jobs. When repairing equipment, oxyacetylene flame may be used to heat metal for bending, forming, straightening, hardening, tempering, and removing paint and rust on equipment.

Oxyacetylene cylinders may be purchased in light-weight sizes for easy handling for moving from place to place on the farm. Usually, it is more economical for a farmer to purchase cylinders due to the demurrage charge if they are used more than one month.

2. The Major Functions of Oxyacetylene Heat

a. Metal is joined by the fusion process. The heated (metal) portions fuse

together forming a weld. The process can be accomplished with or without the use of a welding rod.

b. The joining of metals or metal by adding bronze as a filler is known as brazing. Base metal is heated to a temperature that will cause the bronze to stick and bond the metals together.

c. Soft and hard solders (lead and silver alloys) are the filler materials in soldering. The base material is heated to a temperature that will cause the solder to stick.

d. Oxyacetylene flame is used to bend, shape, preheat, postheat, and temper metals. Heating of metals is one of the most important functions of the oxyacetylene flame.

e. The oxyacetylene flame is also important in separating metals. The metal oxidizes after a kindling temperature is attained and pure oxygen is applied to it. This practice is known as cutting or burning.

3. Description of Oxygen and Acetylene

a. Oxygen (O_2) is one of our most abundant gases. One-fifth of the air breathed is oxygen. It is colorless, odorless, and tasteless and is heavier than air. Oxygen is considered a supporter of combustion. It is produced commercially by causing air to liquify and using fractional distillation to recover the oxygen.

b. Acetylene (C_2H_2) has a distinct odor and like oxygen is colorless. When calcium carbide and water are mixed a hydrocarbon is formed. The equation is $CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$ acetylene and calcium hydroxide. Acetylene burns in both the primary combustion area (cone of the flame) and the secondary combustion area (envelope of the flame). The end of the inner cone may produce a neutral flame temperature from about 5400 to 6300 degrees F. The temperature is raised by adding oxygen.

4. Oxyacetylene Safety Practices

Transparency No. 1

Safety cannot be "Bought", it must be "Practiced"; this is especially true

when working with oxygen and acetylene gases. The most common hazards found in welding are burns caused by heated metal and welding dust, and injuries due to toxic gases or fumes. The weldor should be thoroughly informed regarding all safety practices, including the use of oxygen and acetylene for both welding and cutting.

a. Personal safety rules to observe are:

(1) Be neat and clean about work areas. Keep equipment clean and in good operating condition.

(2) Never use oxygen as air pressure for cleaning or in pneumatic tools. Oxygen must not be used in oil preheating burners, to blow out lines, to create pressure in containers, or any place as a substitute for compressed air or other gases.

(3) Use a friction lighter or pilot lighter to light torches - Never Use Matches to Light a Welding Torch!

(4) Protect the eyes by wearing goggles or head shield with suitable lenses when using a torch.

(5) Wear leather gloves, protective shoes, and clothing that is completely free of oil with pockets and cuffs protected from sparks or hot metal. Do not hang articles of clothing on cylinders, because clothing may become saturated with acetylene and explode or ignite.

(6) Ventilate working areas. Do not use oxygen for ventilation. Make sure that oxygen concentrations above normal cannot be developed in the work area. Leave gas cylinders outside when working in small enclosures.

(7) Always refer to acetylene as "Acetylene" - not "Gas". Refer to "Oxygen" as oxygen - not "Air". The word gas is a general term and confusion here is dangerous. The use of the term "Air" instead of the word "Oxygen" may lead to a serious accident.

b. Safety rules to observe when handling cylinders include:

(1) Keep oil and grease away from cylinders and never use these types of lubricants on the valves or connections.

(2) Use cylinders in rotation as they come from the supplier. Mark the empty cylinders and send marked cylinders back to the supplier promptly. Also, keep "empties" and "fulls" separate to avoid

serious results. Keep the valves closed on "empties".

(3) Keep cylinders away from exposures to sparks, hot slag, open flame, and all possible sources of excessive heat.

(4) Always secure cylinders in an upright position to a suitable support. Letting a cylinder fall can be dangerous. Also, transport and store cylinders in an upright position. Do not attempt to lift cylinders with make-shift equipment. The most popular cylinder mount is a cylinder cart.

(5) Never use cylinders as a ground or a source of an electric circuit. Do not strike an arc on a cylinder with the electric arc unit and do not hit the cylinder with any object, especially if the object is metal.

(6) If cylinder valves cannot be opened by hand, never use a hammer or wrench; notify the supplier and if leaks appear, move cylinders out of shop area and notify supplier.

c. Safety practices to observe when attaching and using the welding unit apparatus are as follows:

(1) Keep all apparatus clean and free from oil. Do not use oil on the regulators-oil and oxygen can cause a dangerous explosion.

(2) Open the cylinder valves slowly after attaching the regulators, allowing the hand on the cylinder gauge to move slowly on the dial away from the pin. A full oxygen tank contains about 2000 psi (pounds per square inch) and a full acetylene tank 250 psi.

(3) Do not use defective or leaky apparatus - have it repaired. Matches or a type of flame should not be used to test for leaks. The use of soapy water is safe when testing for leaks. Use a paint brush to apply the soapy water on all connections.

(4) Stand to one side of the regulators when making valve and regulator adjustments.

(5) Use wrenches on blowpipes and other connections only as directed by the manufacturer. Most blowpipes are designed for hand tightening.

(6) Use as short a hose length as possible. Remember, the longer the

hose, the higher the pressure required. Hose leaks must not be repaired with tape. A leaky hose should be replaced with a new hose. Do not kink the hose, as this practice injures hose linings. Keep sparks and hot metal away from hoses.

(7) Do not attempt to repair torches or regulators unless properly trained.

(8) Never put acetylene under a pressure of more than 15 psi. Acetylene over this pressure is seldom used for welding. This gas is explosive at any pressure if a spark or flame is present in a small closed area.

(9) After finishing a welding job, first turn off the acetylene torch valve and then the oxygen valve. The hose color will identify the two different gases.

(10) Prevent fires by keeping tips clean, using proper pressure, keeping connections tight, properly heating metal, keeping tips firmly seated, and using friction lighter.

(11) Keep fire extinguisher ready to use in case of fire.

d. Some general safety practices to observe include:

(1) Never weld or cut on containers that might have been used to hold flammable materials. Some of the most serious accidents are caused by working on this type of item. The weldor may still be in danger even if the container is filled with water.

(2) Cut and weld when under the supervision of an experienced teacher or weldor. Safety practices are respected by these types of people.

5. Equipment Necessary for Oxyacetylene Cutting and Welding - Setting Up Equipment

Transparencies Nos. 2a and 2b

a. Equipment

(1) Cylinders - The two types of cylinders are oxygen and acetylene. Both types are made to hold gases in cubic feet measures. The sizes of oxygen cylinders are 244, 122, and 80 cubic feet. Acetylene cylinders are measured in 300, 100, and 60 cubic feet.

These cylinders are equipped with a safety device to let the gases drain slowly if heat causes the pressure to rise.

(2) Regulators - Both oxygen and acetylene regulators have two gauges; one gives the amount of pressure in the cylinder and the other the torch pressure. When using a neutral flame the following pressure readings are used for certain makes of welding tips:

Oxygen Pressure	Acetylene Pressure	Metal Thickness	Size of Tip
2 1/2 lbs.	1 lb.	1/16"	1
7 1/2	3	1/8	3
12 1/2	5	1/4	5
17 1/2	7	1/2	8
18 3/4	7 1/2	5/8	9

(3) Cutting Torch - The cutting torch provides a preheat mixture of oxygen and acetylene for heating the metal and a pure stream of oxygen for blowing the heated metal from the intended cut. The torch is equipped with both oxygen and acetylene valves and a cutting valve lever that controls pure oxygen.

(4) Welding Torch - This is also equipped with a gas mixing chamber. The gases are controlled by the two valves located at the back of the torch handle.

(5) Hoses - Special type of non-porous hoses carry the oxygen and acetylene from the regulators to the torch. Oxygen hoses are usually green or black, and acetylene hoses are red in color. Oxygen hoses have right-hand threads and acetylene left-hand.

(6) Cutting and Welding Tips - Cutting tips have four preheat orifices and one cutting oxygen orifice. This orifice is located in the center of the tip. The thickness of metal regulates the size of tips to be used. Welding equipment manufacturers identify tips by both letter and number. Heat and flame from the preheat holes form the inner cone. This cone has a short flame, whereas the cutting oxygen flame is long.

(7) Welding Tips - Different sizes of welding tips, like cutting tips, are interchangeable in the blowpipe. The size is also similar to that of the cutting tip in that it is governed by the orifice. Welding tips only have one orifice. However, the numbering system

which regulates sizes (ranging from 00 to 15) depends on the tip manufacturer.

(8) Necessary Miscellaneous Equipment - The friction lighter is the only safe type of lighting equipment used. It lights both the cutting and welding torch. Open end or adjustable wrenches are used on the regulator and torch connections. Wrenches are usually supplied with a welding unit. In the tip cleaning set, cleaners are made to fit the orifices in both cutting and welding tips, Such items as soapstone for marking, c-clamps for holding stock, and wire brushes for cleaning metal are essential in a welding and cutting outfit.

(9) Weldor's Clothing - The operator should not attempt to cut or weld metal without protective goggles. They protect the eyes against dangerous rays, glare, and sparks. Fire-resistant gloves are recommended for welding to protect the hands against heat radiated by the torch and metal. Clothing should be of the type that protects the body against sparks and heat.

b. Setting up equipment involves the following steps:

(1) Fasten Cylinders - After fastening cylinders either in a portable cart or against the wall, remove the protective caps, and crack valves slightly to clean foreign matter from inside the nozzles, then close the valves.

(2) Connect Regulators - Fasten regulators to respective cylinders and tighten union nuts. Open the regulator adjusting screws by turning counterclockwise until they feel loose, then open the cylinder valves very slowly, allowing the pressure to move the gauge hands (oxygen and acetylene) on the dial very slowly. A T-wrench is used to open the acetylene valve.

(3) Connect Hoses - Attach the red hose to the acetylene regulator and the green or black hose to the oxygen regulator. Note: right-hand threads are on the oxygen hose and left-hand threads on the acetylene hose. It may be necessary to turn the regulator adjusting valves clockwise to blow the hose out. About 5 pounds of oxygen will clean the hoses. If the acetylene hose is cleaned with oxygen, it is attached to the oxygen regulator with a special connection. Assuming the blowpipe needs cleaning, open both blowpipe or torch valves after the torch is connected to the hoses and blow the

torch out with about 5 pounds of oxygen pressure.

(4) Select and Insert Cutting or Welding Tip - After the proper size of cutting tip is selected, it should be tightened with a wrench. The welding tip is tightened by hand. Tips are selected according to the thickness of metal. For example, a welding tip 00 is used on thin metal (1/32 inch or less), whereas a number 14 tip is used to weld thick metal (1 inch and over). The right size tip will let gas flow at the proper rate for fusing metals together.

(5) Turn on Unit - Fully open the oxygen cylinder valve and turn the acetylene 3/4 to one turn open. With the oxygen needle valve open on the torch, adjust the pressure gauge to the desired working pressure, and then close the needle valve. The same procedure is followed for regulating the acetylene.

(6) Test for Leaks - Use soapy water and a paint brush to check for leaks at the following points:

Transparency No. 2b

(a) Oxygen and acetylene cylinder valves
(b) Regulator valve inlets
(c) Hose connections at regulators and blowpipe or torch
(d) Area around needle valves
(e) Area around tip connections

6. Oxyacetylene Cutting Parts and Adjustments

Transparency No. 3

a. A different type of torch (blowpipe and tip) is used for cutting metal than is used for welding. The cutting tip has 3 to 8 holes located around the center hole. These small orifices (holes) furnish flames to preheat the metal, and the center orifice furnishes oxygen to cut the metal.

b. An oxyacetylene cutting torch has three controls. They are: preheat oxygen valve, preheat acetylene valve, and a cutting oxygen valve that is controlled by a lever. The two preheat valves actually furnish heat on the surface to a kindling temperature of the steel being cut and the cutting oxygen controlled by the lever ignites the molten metal and blows it from the heated area.

c. Lighting and adjusting the blowpipe are very important steps when cutting metal. If the manufacturer's instructions are not available, the following procedure may be used:

(1) Hold the blowpipe with the tip pointing away from the body. Open the acetylene valve about 1/2 turn and light the torch with the friction lighter. The flame should clear the tip end about 1/8 inch when first lit, but it should be adjusted back to the tip.

(2) Adjust the regulator pressure by turning the adjusting screws clockwise. Oxygen pressure depends on the thickness of metal being cut, usually 15 or more pounds per square inch. For example, 1-inch thick metal requires about 30 psi. Acetylene pressure varies from 3 to 5 psi and never exceeds 15 psi.

(3) Adjust the preheat oxygen valve until a neutral flame appears with sharp inner cones, then press the cutting oxygen lever and readjust the flame by turning the preheat oxygen valve while the cutting lever is in the downward position. This readjustment is to correct the flame from carburizing to neutral when raising the lever.

7. Cutting Metals

Transparencies Nos. 3, 4, and 5

a. The metal to be cut should be clean, marked with a punch or soapstone, and placed in a suitable position for cutting. The position can also involve the location for cutting. For example, moisture in a concrete floor will cause small pits where the hot metal falls. This can be prevented by using a container to catch the molten metal. Hot metal will also damage welding unit hoses and may even cause fires.

b. Cutting metals by using the oxyacetylene process is more or less limited to ferrous metals such as carbon steels, alloy steels, low chromium steels, and manganese steels. Steels with a high tungsten or chromium content or stainless steel cannot be cut with oxyacetylene heat. Cast iron is more difficult to cut than steel; therefore, an excessive acetylene flame is used to cut thick cast iron. Also more oxygen is needed due to more heat being required than when cutting malleable steel. The cutting tip is held at 45 degrees to start the cut and is raised to about 75 degrees to make the cut.

c. The steps to follow in making a cut are:

(1) Hold the blowpipe perpendicular to the surface of the metal unless bevels are to be cut. Place flame inner cone within 1/16 to 1/8 inch above the plate or metal surface edge. Metal will not stack on the tip if it is held at a proper distance from the surface. Hold the tip so that two preheating holes are in line with the oxygen hole.

(2) Hold the torch at the edge of the metal until the metal begins to melt. The top of the torch may be slanted toward the cut and changed to a vertical position as the cut progresses.

(3) Press down slowly on the oxygen cutting lever until the cutting valve is completely open. When the cut is through the metal, move the torch along the line.

(4) Tilt the torch tip slightly toward the direction of cut on thin metal. It should be held vertical on thick metal when making a straight cut.

(5) Move the torch slowly along the surface or the oxygen stream will not pass completely through the metal. The cut can be restarted by releasing the cutting lever and reheating the metal again before pressing the cutting lever. Irregular edges may be caused by losing the cut.

(6) When beveling plate edges or cutting at an angle, lean the tip at the desired angle and hold the torch parallel to the work.

d. Steps that may be followed when piercing holes include:

Transparencies Nos. 4 and 5

(1) Hold the blowpipe in the same position (tip perpendicular to the surface) until a spot on the surface begins to melt.

(2) Raise the blowpipe (torch) until the end of the nozzle is about 3/8 to 1/2 inch above the surface and slowly press the cutting lever as the torch is raised.

(3) Move the tip to one side of the heated area so that the slag (not-metallic material in the heated metal) can be blown out.

(4) Move the inner cone within about 1/8 inch from the surface and make the cut on the inside edge of the hole.

(5) To facilitate the cutting of a hole in thick metal, drill a hole 1/4 inch or larger by using a twist drill and start the piercing in this hole.

8. Lighting and Adjusting the Welding Blowpipe

Transparency No. 6

a. Steps to observe when lighting the blowpipe include:

(1) Hold the torch in one hand and the friction lighter in the other. The welding goggles should be pulled from the forehead over the eyes.

(2) Open the torch acetylene valve about 1/8 to 1/4 turn with the tip pointing away from the body and cylinder. The lighter should be held about an inch from the point of the tip while lighting the torch.

(3) Open the acetylene valve until the flame stops excessive smoking and breaks away from the tip about 1/8 inch. The flame is then reduced slightly to bring it back to the tip. The valve is opened again very slightly. If there is a backfire, the flame will go out with a pop. Check the pressure, connections, and heated tip to correct the problem.

(4) Open the oxygen valve slowly until a sharp inner cone appears, creating a neutral flame. The neutral flame is recognized as the oxyacetylene welding flame. Even though the neutral flame is used for most welding jobs, the carburizing flame is used for hard surfacing. Flame descriptions are as follows:

(a) Neutral Flame - This flame does not show any acetylene feather. It does not have a feathery edge, but the flame has a sharp inner cone.
(b) Carburizing Flame - This flame is caused by using an excess of acetylene. It has an inner cone and an acetylene feather. It is the largest of the three types of flames, and is usually the first flame to appear when lighting the torch.
(c) Oxidizing Flame - An oxidizing flame has an excess of oxygen. The small inner cone has a sharp point. The main body

of the flame is smaller than the other two types of flames. The flame may be used for braze welding with a bronze rod.

If the oxygen low pressure gauges show there is a lack of oxygen, turn the regulator valve clockwise until the coneshape flame becomes blue; adjust the torch valve until a neutral flame appears.

9. Turning Off the Blowpipe (Torch)

a. First the acetylene valve is closed on the torch and then the oxygen valve is closed. This assures the operator that the flame is out, thus reducing the possibility of a flash-back which is caused by a carbon deposit in the tip.

b. The oxygen torch valve is the second valve closed. This procedure is followed by closing the acetylene and oxygen cylinder valves.

c. The acetylene and oxygen torch valves are opened to release hose pressure and then they are closed again.

d. The acetylene and oxygen regulator adjusting screws are backed out until they are loose.

10. Caring for Welding Tips

a. Welding tips frequently become spattered with metal or other materials that may cause inferior work. Tips are cleaned in the following manner:

(1) The tip point can be rubbed with emery cloth or steel wool; foreign material and metal is removed by this method. The emery cloth may be placed on a flat surface with the grit side up and the tip point passed squarely over it.

(2) Tip cleaners should be used to clean the orifice of the tips. The edge of the orifice should remain square. The cleaner should have the same number as the tip.

(3) If the oxygen valve is opened slightly at the time the tip cleaner is carefully pushed in and pulled out of the opening, the foreign particles will be blown out of the tip.

b. Proper handling of the tip

(1) The threads and seats of tips can be damaged easily; therefore, they should be stored in a rack for protection.

(2) Most tips can be replaced in a welding blowpipe by hand; but if a wrench is needed to set the tip, it should not be overtightened.

(3) Care should be observed when inserting the tip into the blowpipe. Tip threads are very easily damaged; crossthreading will ruin the tip.

11. Preparing Metal for Welding and Proper Positions of Blowpipe and Tip

a. Preparing metal for welding is as follows:

(1) Before a good weld can be made the metal must be free of oil, paint, grease, dirt, rust, and other foreign matter. Metal can usually be cleaned by heating it with the torch and then brushing it with a wire brush.

(2) Thick metal over 1/8 inch thick can be beveled on one or both sides either by using a grinder or by the use of the oxyacetylene cutting torch. Beveled edges will allow the metal to fuse together and make a stronger joint. Metal over 1/2 inch thick should be beveled on both sides. The most common types of bevels are: Single, Double, Single Vee, and Double Vee. Most bevels are cut at about 45 degrees.

(3) Some types of work require that the metal be aligned before welding; therefore, tack welding is necessary to hold the metal in line during the welding operation. The tack welds may become part of the finish weld.

b. Proper blowpipe and tip positions are:

Transparency No. 6

(1) The blowpipe may be held similar to a hammer when welding in a standing position. It can be held like a pencil when welding in a sitting position.

(2) The blowpipe should be held so that the tip will be at a 45-degree angle to the surface. The welding rod should also be held at about a 45-degree angle to the surface and in line with the weld.

(3) The tip should be held about 1/4 inch above the surface. The inner cone flame should be 1/8 inch to 1/16 inch above the metal.

(4) Preheating the metal is very important in making a successful weld; therefore, the flame should be moved in the direction of the weld, and the cone should stay inside the puddle (molten pool of metal).

12. Oxyacetylene Welding Procedures

Transparency No. 7

One of the most important steps in learning to weld with oxyacetylene is to carry a molten puddle of metal along the line or seam of the parts to be joined together by the weld.

a. Forming the puddle and running the bead include the following practices:

(1) The flame is held at the starting point until a bright round pool (1/4 to 3/8 inches in diameter) is formed. This puddle width is actually determined by the depth of penetration and motion of the torch. If a 3/16 inch wide puddle or pool is formed, the speed of welding should maintain that width. If the speed is correct, the puddle will be formed under the inner cone of the flame. Usually, the inner cone is held from 1/16 to 1/8 inch above the surface. If the speed is too slow, the torch flame will burn a hole through the metal or form a large pool. If the speed is too fast, the bead will be irregular and narrow.

(2) There are several types of torch movement patterns, but the most common pattern used by the experienced weldor is the circular motion, especially when fusion welding with the torch is being done. The weaving or zigzag pattern is also used with fusion welding, but with the use of a filler rod. When using either pattern, the torch should be held at about 45 degrees to the surface or weld. The welding filler rod should be held at 45 degrees but slanted away from the torch tip.

It is recommended to use a rod equal to the thickness of the metal. The torch may be held so the tip is pointed in the direction of the weld (forehand) or the tip pointed toward the weld (backhand).

(3) After a bead is finished, it should be examined for the following characteristics:

(a) Uniform width
(b) Free of excessive scaling
(c) Clean and bright
(d) Slightly higher than the base metal surface and penetrating the base metal.

b. When using a welding rod to make a fusion weld the following procedure may be used:

(1) Select two pieces of 16-gauge sheet steel about 3 inches long and 2 inches wide and a 1/16-inch filler rod.

(2) Slightly bevel the 3-inch sides and tack weld at each end, leaving a very small space (about 1/16 inch) between the two pieces.

(3) With the torch in one hand and the welding rod in the other, heat the two pieces at the starting point (one end) and then heat the welding rod before dipping it into the molten puddle. Make an up and down motion of the rod and at the same time make a circular or zigzag motion with the torch. When using the circular motion remove the rod from the puddle as the flame is moved to the rear of the puddle. Before starting the weld, heat the rod 8 inches from the welding end and bend it at this point to about a 120-degree angle. It is easier handled in this shape.

(4) As the second tack weld is reached, remelt it into the pool or puddle.

13. Welding Positions

Transparency No. 8

Learning to make a welding bead is the first step in learning to master the skill of oxyacetylene welding. The second important step in mastering the skill is to become proficient in welding in several positions. The four most important positions are:

a. Flat Position - The flat position is practiced while learning to weld a bead and fuse metal without the use of a welding rod. This position is known as the downhand position. The following steps are used to make a flat weld.

When welding heavy metal, hold the torch in the manner a hammer is held.

If the metal is thin, hold the torch in a pencil manner.

The flame is pointed in the direction of the weld at about a 45-degree angle.

A right handed weldor usually starts the weld at the right edge of the metal. The inner cone of the neutral flame is usually held within 1/8 inch of the surface to the welded.

The torch is moved forward and rotated at the same time to form a series of overlapping ovals at the back edge of the puddle. The torch should not be moved ahead of the molten metal (puddle). The welding rod should be raised and lowered as the puddle is moved forward.

The welding rod is held at about a 45-degree angle ahead of the torch. A bent rod is easier to handle than a straight rod in front of the flame.

The rod tip is inserted in the molten pool of base metal, where it is melted. A weak porous weld is caused by the rod metal being burned above the puddle.

The welding rod must be held in the center of the puddle; otherwise, it will have a tendency to stick.

In order to form a bead of uniform width and height, the puddle must be carried forward just right. If the movement is too fast, the rod will not fuse with the base metal. If the movement is too slow, the puddle will be too large.

When a puddle is too large, withdraw the flame so that the outer envelope (outer part) touches the molten metal. Do not move the entire flame alloy from the puddle. Air causes the hot metal to oxidize.

The types of welds that are common to the flat position are:

Butt	Lap
Corner	Fillet

b. Vertical Position - Vertical welding is usually done by welding from the bottom up.

Hold the torch so that the tip will point upward at approximately a 15- to 30-degree angle. The rod is held at about the same angle in the other direction.

Make a very small motion with the tip so that the gas velocity will keep the molten metal in place. A large torch motion will cause the molten metal to sag or fall. If the puddle gets too fluid, the flame is directed toward the filler rod.

c. Horizontal Position - The torch and rod are held at about the same angle to the metal as when welding in the flat welding position.

Point the torch tip slightly upward and direct the flame along the lower edge of the two pieces of metal. The position of the torch will help reduce a build up of metal on the bottom piece. Weave the flame from one side of the bevel to the other, holding it slightly longer on the lower edge.

Add metal to the weld from the welding rod by the same procedure that is used in vertical and flat welding.

d. Overhead Position - Overhead welding is more difficult than flat welding, but it is not much harder than vertical or horizontal welding. It is the most difficult position to actually see the weld while it is being done.

Hold the tip at approximately 90 degrees to the work and hold the rod at approximately a 45-degree angle.

Maintain a shallow puddle to eliminate molten metal dropping from the weld. Usually less heat is required than welding in the flat position.

Use a semicircular motion with the torch and move the rod in a circular swinging motion.

If the puddle becomes too large or fluid, raise the torch flame. The flame should be directed to the center of the work instead of one side.

The weld is usually made by moving the torch from right to left.

14. Selecting the Proper Size of Welding Tip and Size of Rod for Certain Thicknesses of Metal

Tips are made in various sizes to provide different degrees of heat. The amount of heat increases as the size of orifice (drill size of a hole in the tip) increases. The neutral flame will remain at about 5900 degrees even though the quality of heat may change. The use of the proper tip size is very important for making a good fusion weld.

Listed below are the approximate size of tips and rods to use when welding steel.

Tip Size (Orifice)	Rod Size (Inches)	Thickness of Metal (Inches)
74	1/16	1/32
69	1/16	1/16
64	3/32	3/32
57	1/8	1/8
55	3/16	3/16
52	3/16	1/4
49	1/4	5/16
45	1/4	3/8
42	1/4	1/2

15. Making the Common Types of Welds

Transparency No. 9

a. Butt Weld - Butt joints are made by placing the edges of metal material together. If the metal is less than 1/8 inch thick, it is usually not necessary to bevel the edges. The steps in making a butt weld are:

Bevel the edges or groove out the place that is to be welded to insure proper fusion and penetration.

Space butt joints far enough apart to allow normal expansion (1/16 inch for 1/8 inch thick steel plate) when heated.

If two separate pieces of metal are welded together, they should be tacked together. Hold the rod and blowpipe at about 45-degree angles; heat the areas to be tacked until two small puddles appear on the two pieces. Add filler metal from the rod and bridge between the two small puddles.

Remove the flame to permit the metal to solidify. It may be necessary to tack weld long pieces of metal in several places.

Examine the finished butt weld to see if it is of uniform width, height, and ripple. Examine the underside for even penetration. A good steel weld will bend 90 to 180 degrees before breaking.

b. Corner Weld - Corner welds may be made without the use of a fusion rod. If two pieces of metal are placed together with the inside corners touching,

a perfect trough or vee is formed for using a filler rod. Steps involved in making a corner weld without and with a filler rod are:

Place the inside corners of two pieces of metal together to form a vee. Tack the edges.

Hold the torch so that the tip is pointing in the direction of the weld at about 45-degrees. Form the puddle at the right end of the joint. A left handed weldor may start the weld at the left end of the joint.

Move the torch in a weaving motion and slow enough that both pieces of metal will be fused together.

When using a filler rod to make a corner weld, space the metal pieces about 1/16 inch apart to get the proper penetration.

Weld a bead slightly thicker than the base metal.

Examine the weld for defects. Corner welds may be made stronger by beveling one piece of the metal.

c. Lap Weld - Lap welds are made by overlapping pieces of metal. It is considered a strong type of weld. The edges of one plate are welded to the face of another plate. Use the following steps to make a lap weld:

Overlap two pieces of metal and tack the edges to the face of each piece.

Hold the rod and the welding tip at about the same angle as when making butt welds.

Move the torch in the same way as when making a butt and corner weld; however, it is necessary to control the flame to prevent melting the edges of the tip plate while forming the puddle in the bottom of the vee.

Weld both overlapping edges to give the lap joint strength.

d. Fillet Weld - The fillet weld is commonly known as the T weld. It is made by welding pieces of metal together at a right angle. Generally, the lap and corner welds may be classed as fillet welds. The weld is made similarly to the lap weld, in that the puddle must be welded equally on both pieces of metal. The steps for making this weld are:

Tack two pieces of metal together in the form of a T.

Start the puddle at the right-hand end of the joint. Move the torch in an oval motion to melt both pieces at the same time.

Move the flame along the joint and direct it more to the flat piece of metal than the upright piece. The torch is held at about the same angle as when welding a lap joint.

Filler rod is added to the fillet weld in the same manner as the lap weld; as the puddle forms in the corner, the filler rod is added. The metal should be at the same height on both plates.

16. Forehand and Backhand Welding Methods

Transparency No. 10

a. Forehand Welding - In the forehand method, the filler rod is moved ahead of the blowpipe tip from right to left (right-handed weldor). The flame is pointed in the direction of the weld.

This welding method may be used to an advantage for thin material, due to the flame pointing away from the weld and the rod helping to control the heat ahead of the molten pool. The main disadvantage of this method is that beveled edges must be completely melted to provide adequate fusion of the filler rod and base metal.

Uniform heat is provided along the path of the weld by manipulating the torch tip in a semi-circular back-and-forth movement. The rod may be moved up and down, avoiding the welding cone tip, but keeping it inside the outer flame envelope. The rod may also be moved in a back-and-forth motion.

b. Backhand Welding - The movements of the torch and rod are from left to right (right-handed weldor) when welding by this method. The rod is held between the completed weld and the flame, and the flame is pointed in the direction of the completed weld.

A back-and-forth movement of the torch and rod to the edges of the bevel may be used. If the flame is directed properly on the edges of the vee, this movement may not be necessary. However, it is necessary to manipulate the filler rod (oscillating motion) from side to side in the puddle.

Usually a 60-degree vee is sufficient to do backhand welding. Forehand

welding requires a wider vee; therefore, more filler rod is needed. Also, more fuel and time is needed to weld a wider bead when using the forehand method.

It is easier to burn through the vee when using the backhand technique than when using the forehand technique. Some authorities state that backhand welding is the best method of welding for deep penetration and complete fusion of thick metals.

17. Welding Sheet Steel

Many farm machine bodies are made of sheet steel. Cracks and torn places on combines, balers, tractors, trucks, and many other types of machines may be repaired by the oxyacetylene welding process. The welds can be as strong as the base metal when properly made. Regardless of the thickness of the metal, it is advisable to use a filler rod in order to obtain a strong weld. The procedure for welding sheet steel is as follows:

Transparency No. 11

a. Adjust the torch to a neutral flame and select the proper size rod for the metal to be welded. For example, use a 3/32 inch rod for 3/32 inch metal.

b. Direct the torch flame in the direction the weld is to be made. Position the white cone so that it does not quite touch the metal.

c. Hold the torch in one place until a small puddle forms and the metal begins to flow together.

d. Preheat the filler rod by placing it within 3/8 inches of the flame and about 1/8 inch from the puddle.

e. Dip the end of the rod into the puddle as metal is needed in the weld. Add enough rod metal to form a slight crown.

f. Withdraw the rod as described previously, but keep it in preheat distance of the flame.

g. Move the torch forward at the constant speed, keeping the slant the same, and add filler metal at consistent intervals.

h. Move the flame in a small circle or make a zigzag motion with the tip

to help spread the heat evenly and cause the metal on both edges to fuse properly. Move the rod in an up and down or zigzag motion.

When welding cracks or torn places on farm machines, the joints may be made stronger by reinforcing with a strip of metal. All metal should be free of grease, paint, dirt, and rust before attempting a weld. Edges or thin metal should be brought together before starting a weld. The edges should be tacked. The tack welds should be 2 to 4 inches apart.

If overheating signs appear or puddles melt through, a smaller tip should be used or the acetylene pressure reduced.

18. Welding Heavy Steel Plate

There are many places on farm machines where steel over 1/4 inch is used. Welding heavy steel plate requires knowledge and skill in handling a large amount of heat, large puddle, and a large amount of filler metal. Welding thick steel is also different from welding thin steel in the following ways:

Joints should be beveled; multi-lay welding is required for large vees; good fusion must be maintained up the sides of the vee; and a different welding technique (backhand) may be used. The procedure for welding heavy steel plate is as follows:

a. Bevel the edges so that they form a single bevel if the metal is less than 1/2 inch. The angle for both pieces of metal should be between 60 and 90 degrees. Make a double-vee joint on metal over 1/2 inch thick. Bevels are made with a cutting torch. Remove all slag and scale from the bevels. Leave a root face (straight edge at bottom of bevel) of about 1/16 to 1/8 inch on single and double vee edges.

b. If the steel plate or heavy metal is in two complete pieces, space the pieces about 1/16 inch apart for welding.

c. Select the filler rod according to the thickness of metal. For example, use a 1/4 inch rod on 1/2 inch metal. A No. 42 tip is recommended for welding 1/2 inch metal.

d. Tack the metal at each end of the weld if the welding distance is 3 or 4 inches. If the welding distance is several inches, tack welds should be every 2 to 4 inches.

e. Melt a puddle at one edge of the plate, heating both sides evenly. Use either the forehand or backhand method for welding the bead.

f. Bring the filler rod into the line of heat as previously mentioned in welding thin metal. Heat the filler rod near the melting point and introduce it in the puddle.

g. Place a bead the full length and in the bottom of the vee. Use a zigzag or circular motion with the blowpipe and move the rod back and forth in the puddle.

h. Make a second bead (weld) in the reverse or same direction but in the same manner as the first bead. Fill the vee almost full of filler and base metal.

i. Reverse the direction of travel and place a third layer of metal on the second layer. Fill the vee slightly above the surface of the plate or object that is welded.

j. If there are parts on machines made of high carbon steel (0.80 percent carbon), the areas should be preheated to a red color and welded with high carbon rods. Machine springs are made of high carbon steel.

19. Welding Gray Cast Iron

Many machine parts are made of cast iron. Machinery gears, frames, gear boxes or housing, and engine blocks are made of gray cast iron. It is important that a machine repairman be familiar with processes involved in repairing cast iron parts on machinery and equipment.

Cast iron oxyacetylene welding procedure is as follows:

Transparency No. 12

a. Clean the cast iron area to be repaired of paint, dirt, and grease. Partial cleaning may be done with the torch and a steel brush.

b. Match the parts to be welded and cut, chip, or grind a bevel along the break line. Grind the beveled surface if a torch is used to make the cut.

c. Preheat the entire area to a dull red before welding. Preheating helps

prevent cracking of the metal during the cooling period. Move the flame slowly over the area to be welded. Small areas can be heated by the torch; large areas must be heated in a furnace. If possible postheat the metal and let cool slowly. Cover the welded area with asbestos paper until it is cool.

d. Select the proper size tip for the job. The size of tip used for steel can be used for cast iron.

e. Select a cast iron rod that contains the proper amount of silicon. These rods are available in 1/8 and 1/4 diameter by 18 and 24 inches in length. A high quality alloy cast iron rod will contain enough silicon.

f. Apply the neutral flame heat to the bottom of the vee until the metal begins to melt. Hold the torch in about the same position as in welding steel. Keep the inner cone from 1/8 inch to 1/4 inch away from the seam.

g. Move the rod from side to side and melt down the metal so that it will combine with the fluid metal in the bottom of the vee.

h. Move the torch in a circular motion to keep the metal fluid. If the fluid metal appears too hot or tends to run away, raise the torch to reduce heat.

i. Bring the filler rod into the outer flame and as soon as it is hot, place the end into the cast iron welding flux.

j. Return the flux end to the molten puddle. The molten metal will rise in the vee as the rod melts. Do not continue dipping the end of the rod in the puddle at the same speed as when welding steel. The molten puddle may be stirred with the end of the rod to bring oxides and gas pockets to the surface. Play the flame to bring impurities to the top of the weld.

k. The motion may also be oscillating with both rod and torch as the weld is advanced inch by inch.

l. Bring enough cast iron rod and base metal together to form a slight crown. Generally, no ripples will appear on the surface of a cast iron bead.

20. Welding Aluminum

Aluminum and aluminum alloys are used in the manufacturing of machine parts and different types of small engines. Some of the ways that aluminum differs from other metals are:

It oxidizes with ease at high temperatures, melts before it changes colors,

conducts heat faster and shrinks more on cooling than cast iron, and becomes very weak near the melting temperature.

The characteristics of a good steel joint weld apply to welding an aluminum joint. These characteristics are:

Proper fusion
Proper penetration
Weld in line with seam
Proper crown
Clean appearance

The procedure for welding aluminum is as follows:

Transparency No. 13

a. Prepare straight flanged joints when possible before welding sheet aluminum less than 1/16 inch thick. Notch joints on sheet 1/16 to 3/16 inch. Notches may be made with a hacksaw or chisel. Notches help prevent distortion, aid penetration, and reduce the possibility of burning holes through the pieces of materials.

b. Bevel the edges of joints if the aluminum plate is over 3/16 inch thick. Cut notches at the lower part of the bevel. The edges may be beveled to form a 90 to 120-degree vee. Leave a 1/16 inch root space on aluminum plate. Double - vee bevels are notched on metal more than 3/8 inch thick. In general, the edges of steel and aluminum are prepared for welding in the same manner.

c. After the edges have been cleaned, jig the material to keep it from buckling and collapsing when heat is applied.

d. Preheat the area to be welded on cast aluminum regardless of the thickness. Preheating will minimize cracks and reduce expansion. Move the flame over the work to preheat the material. One of the well known methods to determine the proper preheating temperature is to mark the preheating area with carpenter's blue chalk and heat the material until the chalk turns white.

e. Use a tip slightly larger than is recommended for steel of the same thickness. Adjust the flame to neutral or slightly reducing. Never use a "blowy" flame.

f. Select the proper rod for welding. A filler rod equal to the thickness of the metal is usually used. The four most common sizes of rods are: 1/16, 1/8, 3/16, and 1/4 inch diameter. Commercially pure aluminum is welded with 1100 welding rod. Aluminum that contains alloys is welded with 4043 or 5356 welding rods.

g. Make a paste flux by mixing three parts of aluminum flux in one part of water. Coat the metal and the welding rod with the paste before starting the weld. The fumes from the flux can be dangerous. The weldor should avoid breathing the fumes.

h. Adjust the flame to neutral or slightly carburizing so that the metal will not oxidize. If the flame is greatly reduced, the metal will have a dirty appearance.

i. Melt the flux over the surface to be welded with the torch. Melt the base metal and then apply the rod. The rod should remain under the flame long enough to deposit the rod metal. Use a circular motion to weld the bead. Forehand welding is considered the best method for welding aluminum, because the forward flame helps preheat the base metal.

Cast aluminum is welded in about the same manner as wrought aluminum. A steel paddle may be used to stir the molten metal, remove oxidized aluminum, and smooth the surface of the bead.

21. Bronze Welding

Transparency No. 14

Most repair and rebuilding jobs on farm machines can be accomplished by bronze welding. It is a convenient way to join steel, malleable steel, cast iron, and several other metals together.

Bronze welding is very frequently referred to as braze welding or brazing. The American Welding Society defines braze welding as "A method of welding whereby a groove, fillet, plug, or slot weld is made using a nonferrous filler metal, having a melting point below that of the base metals, but above 800 degrees F. The filler metal is not distributed in joint capillary attraction."

Bronze welding resembles soldering in that the base metal is not melted together with the bronze metal. There is a strong bond formed between the base metal and rod metals in a proper weld.

The advantages of a bronze weld are:

Lower welding temperatures are needed; therefore, time and gas is saved.

Due to the low temperatures used to make a bronze weld, there is less chance of changing the base metal characteristics. For example, expansion and contraction

are not as great where less heat is required.

Less preheating is used in bronze welding than wrought or cast iron welding.

Bronze welding is adaptable to many kinds of metals.

The disadvantages of bronze welding are:

The bronze weld may not withstand the same amount of stress as a steel weld.

Bronze tends to lose its strength if subjected to temperatures above 500 degrees F. ; therefore, parts on a machine that operate at high temperatures should not be welded with bronze. The filler rod is made up of copper and zinc with small quantities of silicon, tin, iron, and manganese.

The procedure used in bronze welding is as follows:

a. Free the surface to be welded of any grease, paint, dirt, corrosion, or rust. The molten bronze will flow over a properly heated and clean surface. The surface may be cleaned by grinding, sanding, filling, chipping, or a combination of these cleaning processes.

b. Prepare the joint to be welded in the same way as preparing joints for other welding processes. Butt, lap, and tee joints are welded without beveling if the base metal is less than 1/8 inch thick. Bevel metal that is over 1/8 inch thick. Butt welds should be spaced about 1/15 to 1/8 inches apart. A larger bonding area is provided if the vee-groove is at least 90 degrees. Metal that measures more than 3/8 inch thick should be double beveled.

c. Select the proper size welding tip for a specific job. Different thicknesses of metals require different sizes of tips. A tip that is too large will burn the bronze and cause it to flow too freely over the joint. Listed below are tip sizes for bronze welding:

Size of Tip (Orifice)	Size of Rod (Inches)	Thickness of Metal (Inches)
69	1/16	1/16
57	1/8	1/8
52	3/16	1/4
45	1/4	3/8
45	1/4	1/2

d. Use a slightly oxidizing flame for bronze welding. Light the blowpipe with an excess feather of acetylene. Add oxygen until feather disappears; then add just a small amount more oxygen. Point the tip of the blowpipe in the direction of the weld and angle it at about 45 degrees. Do not operate the blowpipe at high pressure.

e. Preheat castings with the torch to a cherry red. Move the bronze rod into the outer flame and heat before dipping it into the flux. When welding two separate pieces (butt weld) together, tack weld the pieces, spacing the tacks a few inches apart. There is a special flux for most metals. Under certain conditions flux may be sprinkled on the metal and heated.

f. Move the flame in an arc or oval and move the rod back and forth in the opposite direction from the flame. Keep the rod close enough to the flame that it will not freeze. Each time the rod is melted to the end of the flux, heat and dip it again.

g. To do proper tinning (thin film of metal) the correct amount of heat, adequate amount of flux, and adequate amount of bronze must be used over the surface to be welded. Proper tinning is very important when welding cast iron. A thin layer of the bronze molten metal adheres to the cast iron, forming a footing for the succeeding weld.

h. Make as many passes as necessary to fill the vee or weld. The final bead should make a slight crown.

22. Hard Surfacing Practice Procedure

Hard surfacing is the application of an all alloy material to another metal for the purpose of reducing wear. Metals that are subjected to abrasive wear such as cultivator sweeps, plow shares, and horseshoes can be hard surfaced.

The procedure for hard surfacing is as follows:

Thoroughly clean the metal before applying alloy.

Place the material to be hard surfaced in a flat position.

Heat a small section of the area with a welding flame that contains an excessive amount of acetylene until the metal begins to sweat.

Touch the tips of the alloy rod to the surface and melt enough of the rod to form an alloy cover 1/16 inch thick and a desirable width without heating the base metal to a melting point.

Maintain a hard surfacing temperature in front of the path of the hard metal. Add just enough of the rod to the metal to maintain a uniform thickness and width. The width will vary according to the material being welded.

Hard surfaced metal should be allowed to cool slowly. Ashes or dry lime serves as a good cover for cooling metal.

References:

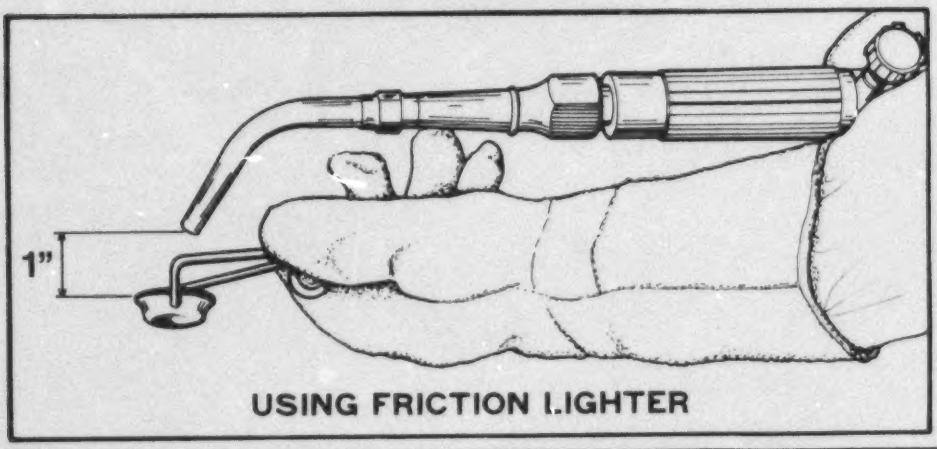
1. Althouse, Andrew D., and Others, Modern Welding, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1976

2. Griffin, Ivan H., and Edward M. Roden, Welding Processes, Delmar Publishers, Inc., Albany, New York, 1970

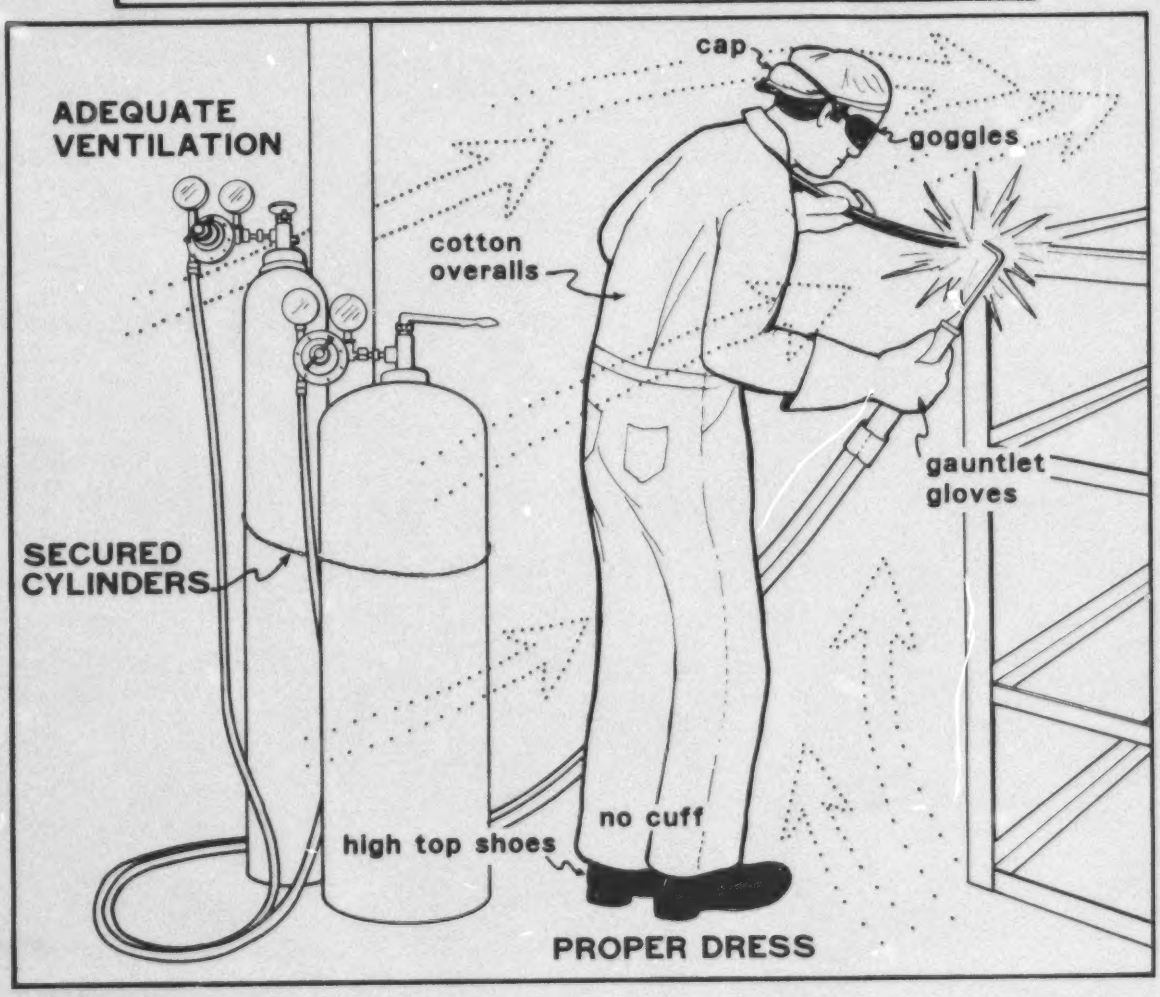
3. Morford, V. J., and Others, Metals and Welding in Agriculture, Hobar Publications Division of Hobar Enterprises, Inc., St. Paul, Minnesota, 1970

4. "The Oxy-Acetylene Handbook" Union Carbide Corporation - Linde Division, New York, 1976

SAFETY PRACTICES



USING FRICTION LIGHTER



PROPER DRESS

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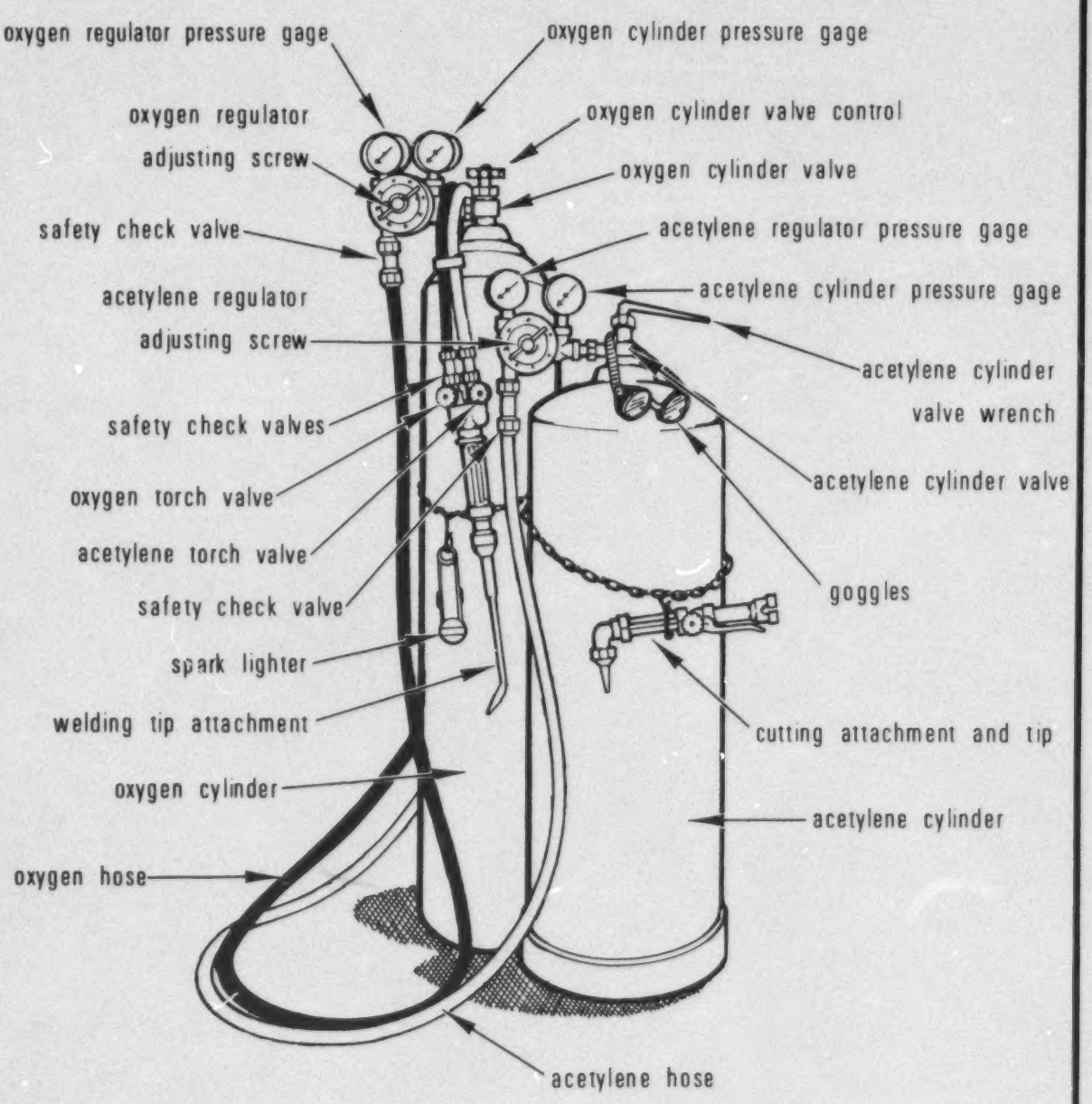

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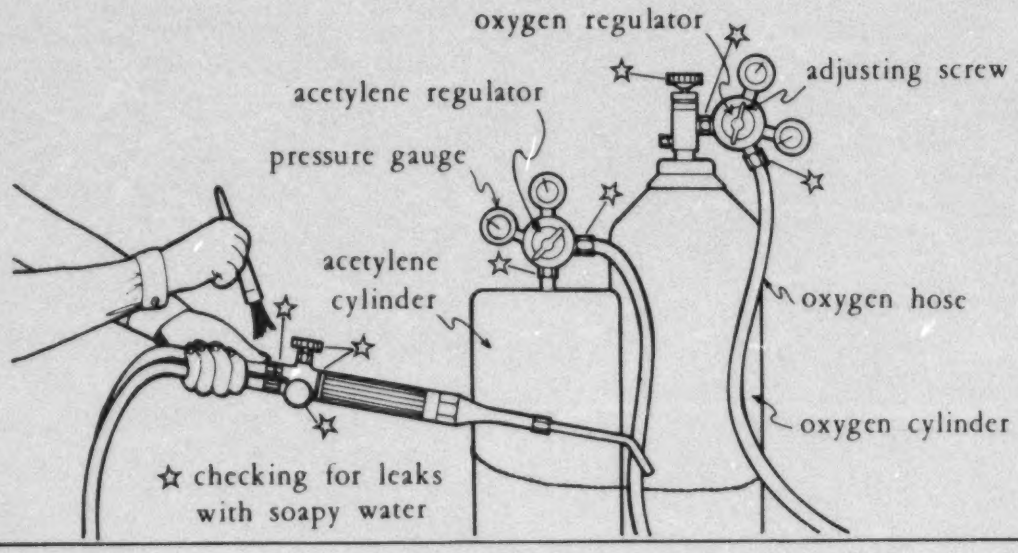
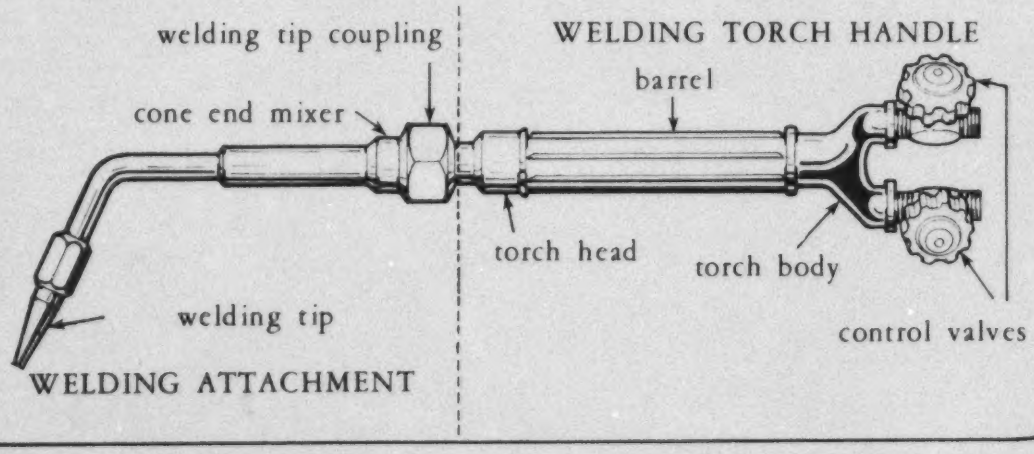
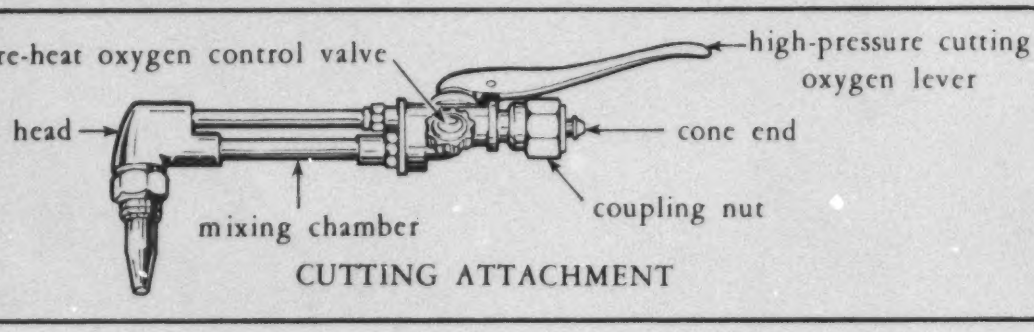
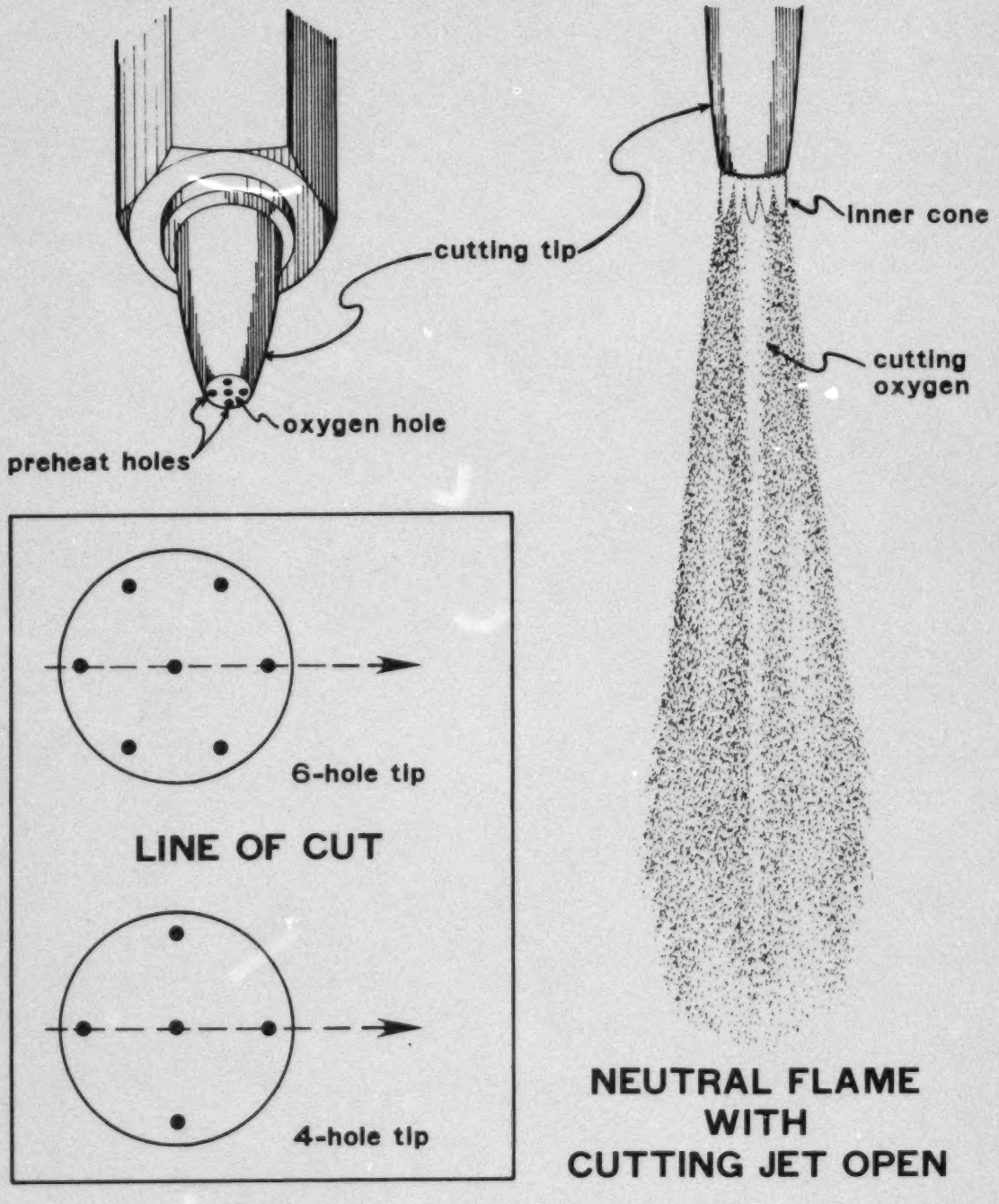


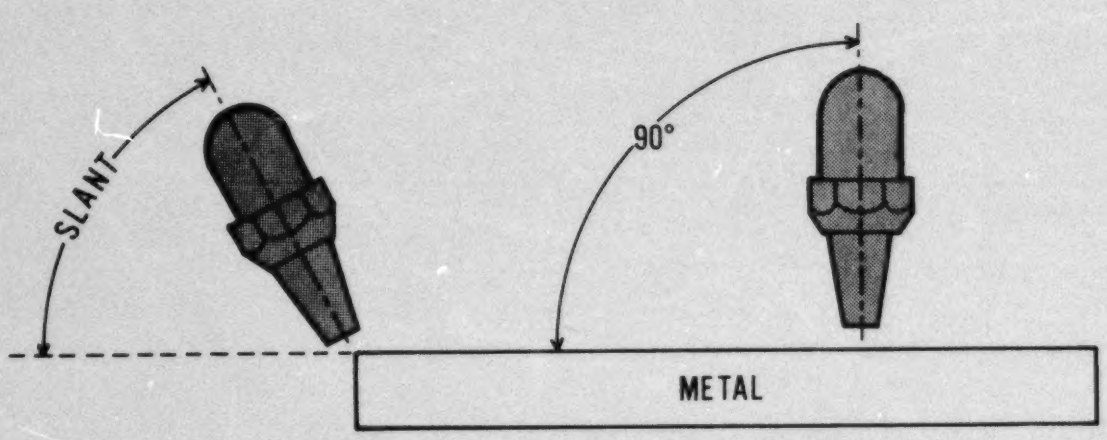




OXYACETYLENE CUTTING

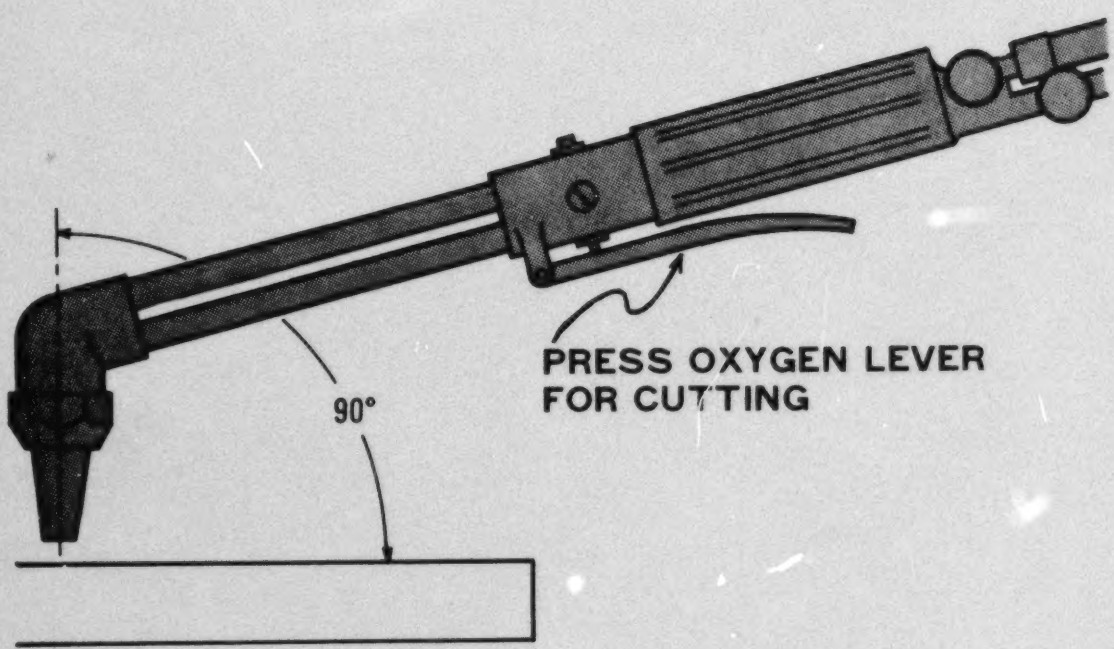


CUTTING METAL



TORCH TIP SLANTED TO START CUT

GRADUALLY MOVE TORCH TIP TO PERPENDICULAR POSITION



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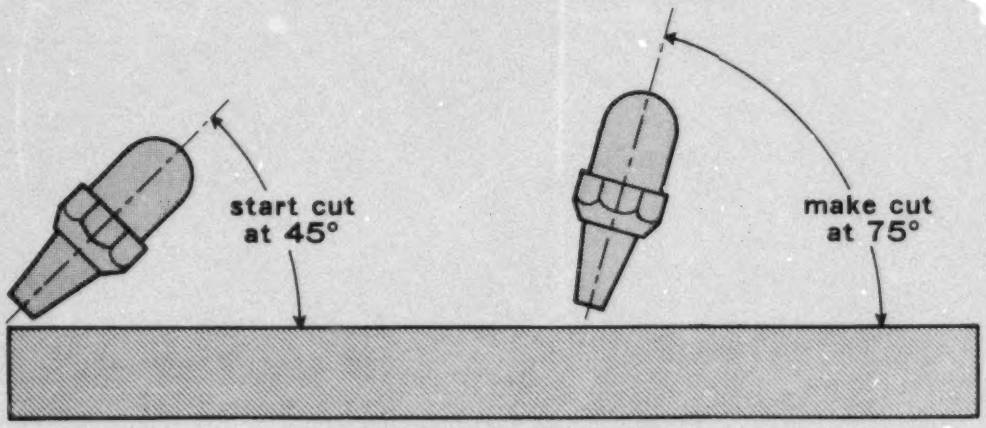
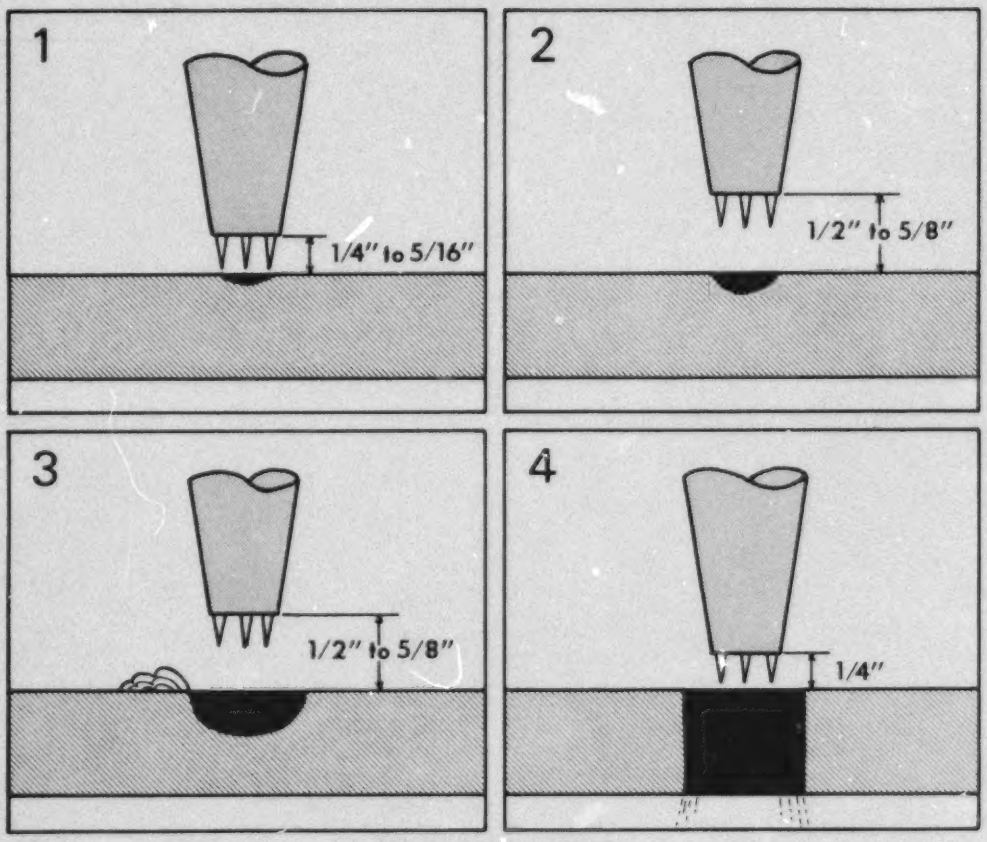
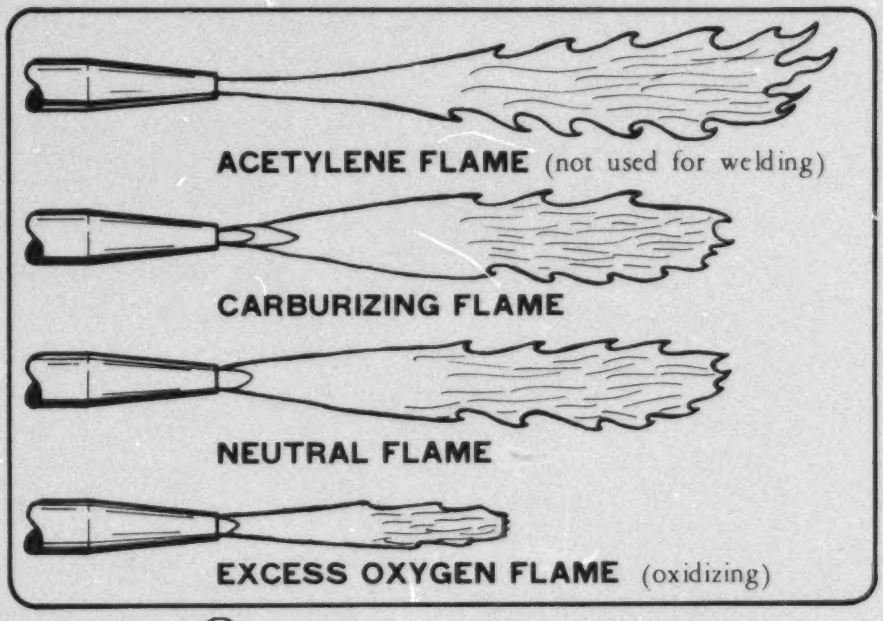


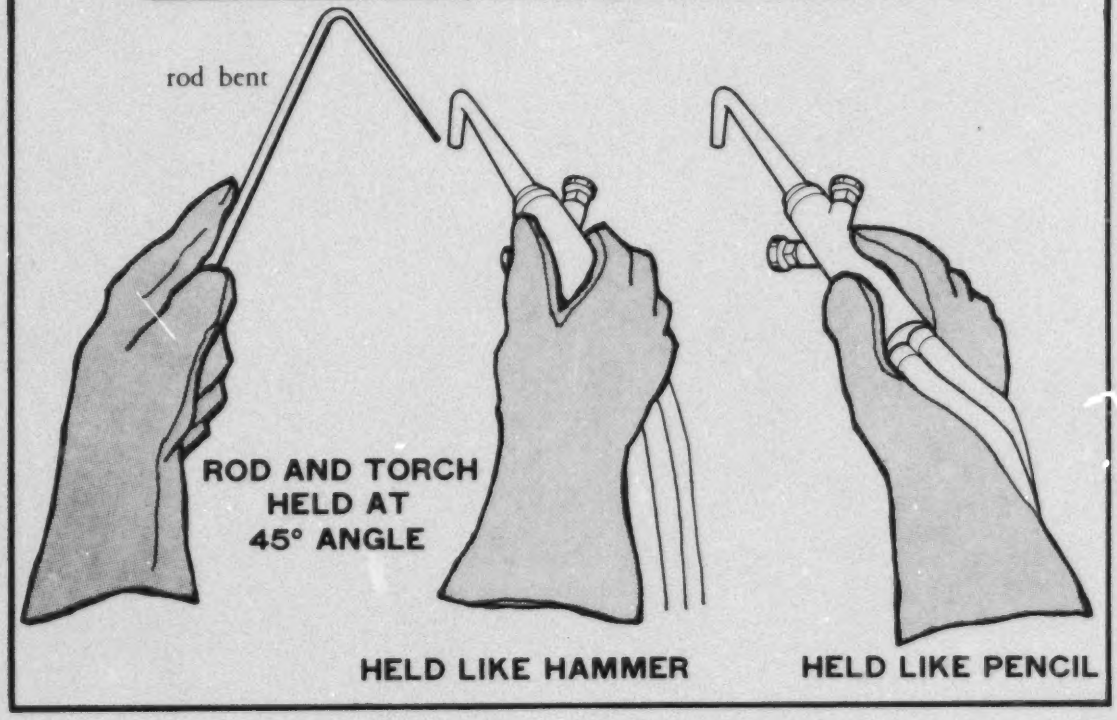
CUTTING CAST IRON



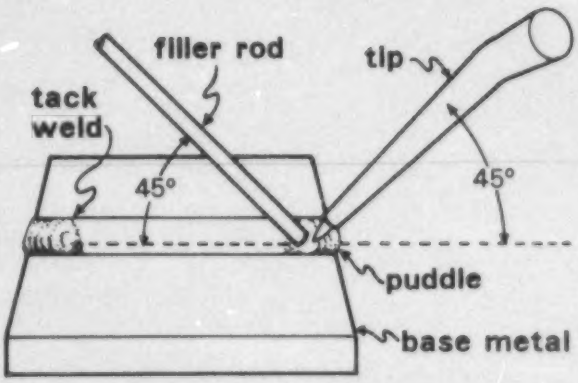
PIERCING HOLE

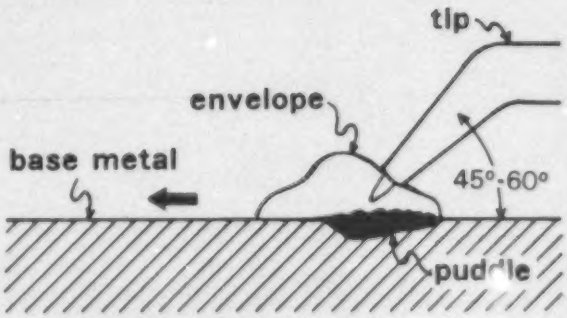
KINDS OF WELDING FLAMES AND TORCH POSITIONS

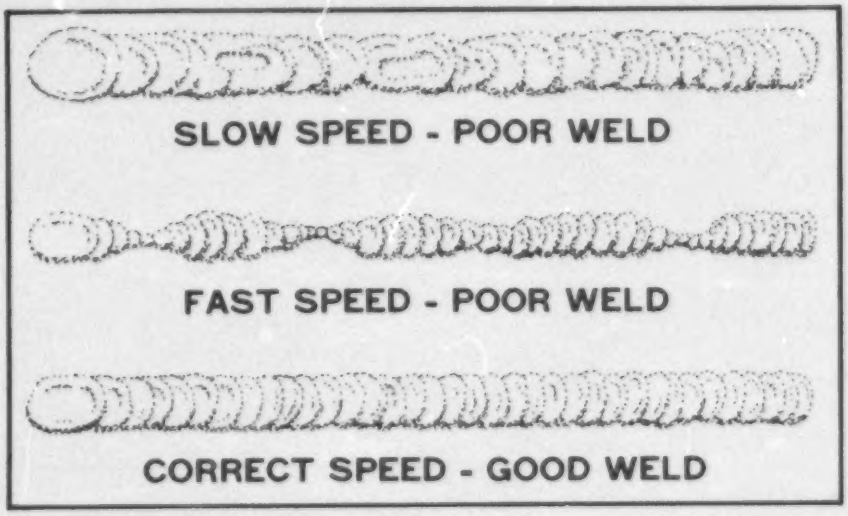


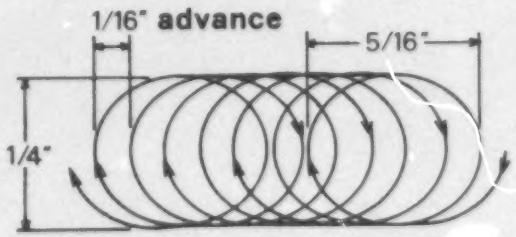


WELDING PROCEDURES

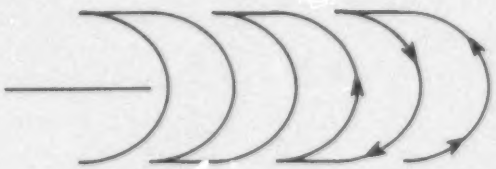






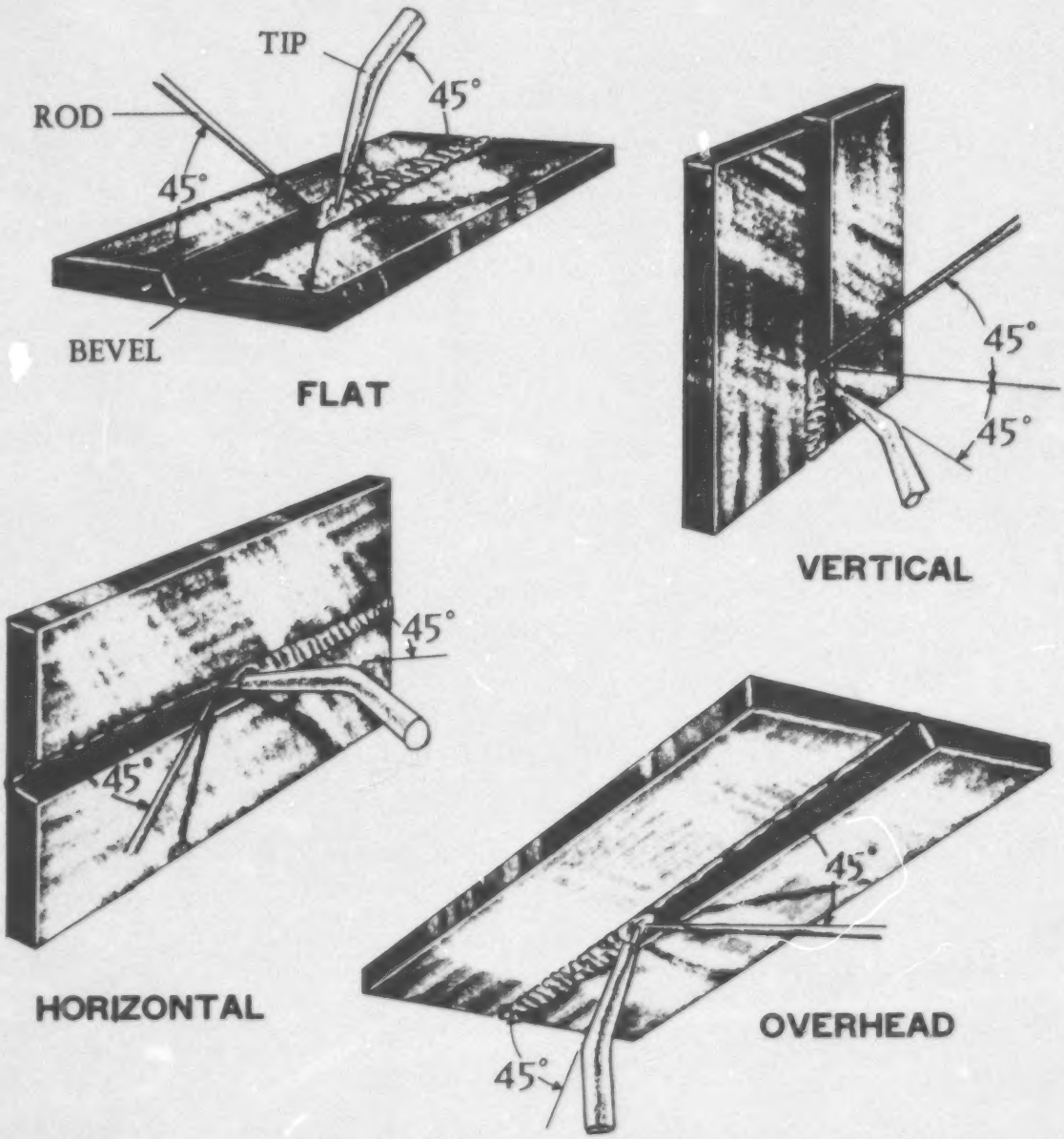


CIRCULAR MOTION



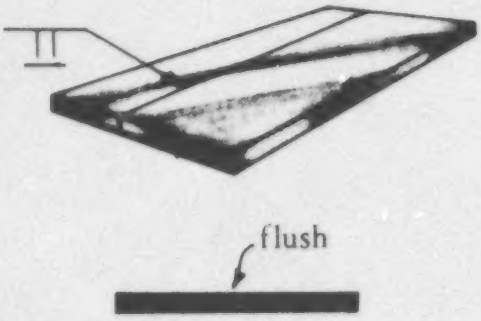
ZIGZAG MOTION

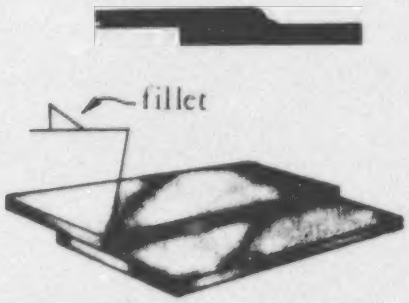
OXYACETYLENE WELDING POSITIONS



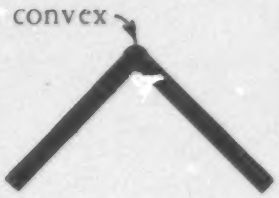
TYPES OF WELDS AND SYMBOLS

BUTT

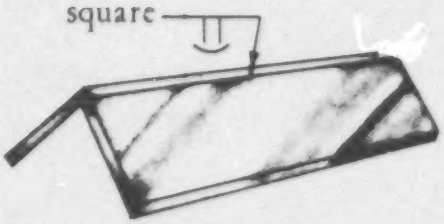


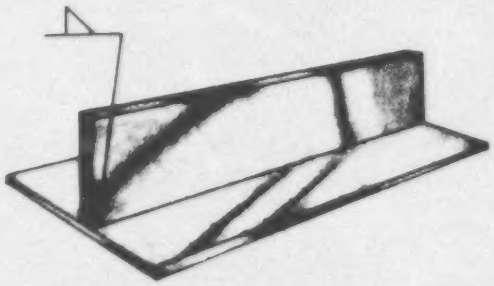


LAP



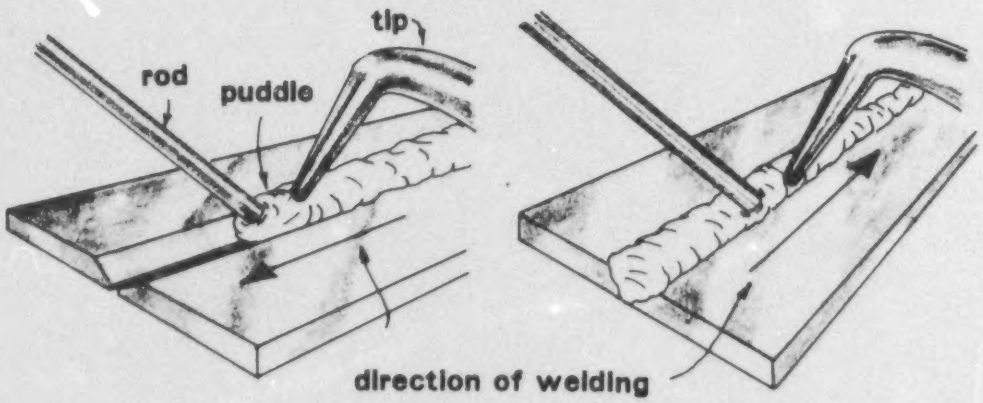
FILLET





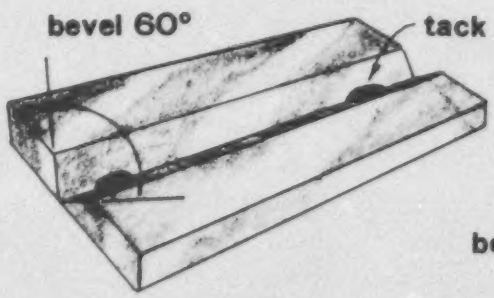
CORNER

WELDING POSITIONS

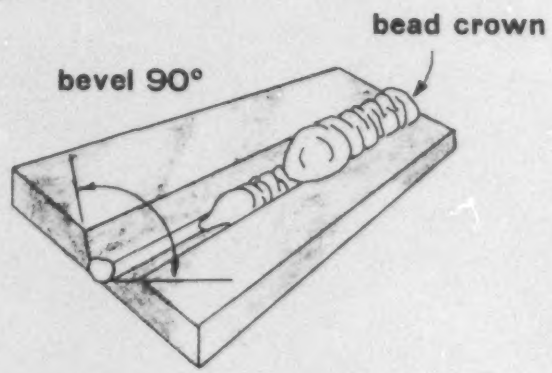


FOREHAND WELD

BACKHAND WELD

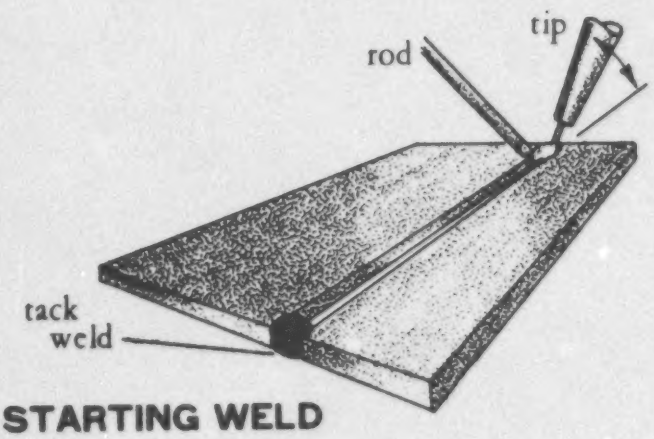


BACKHAND WELD BEVEL

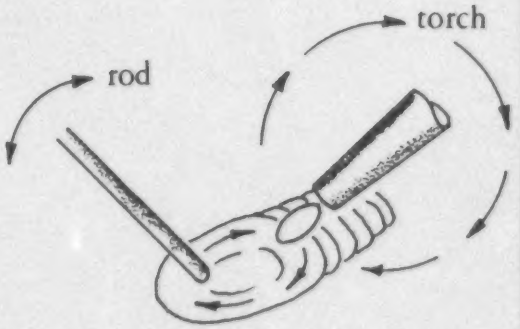


FOREHAND WELD BEVEL MULTI-PASS

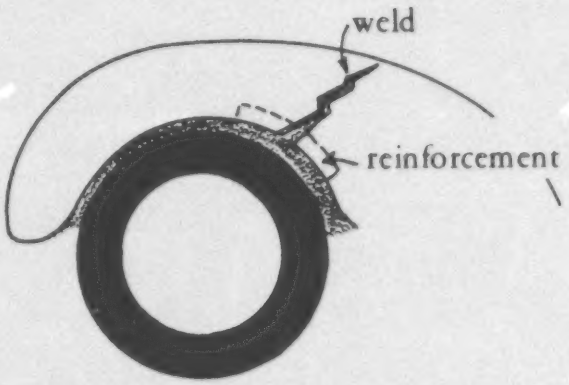
WELDING STEEL



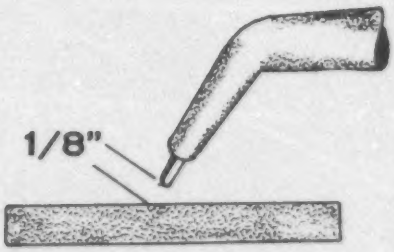
STARTING WELD



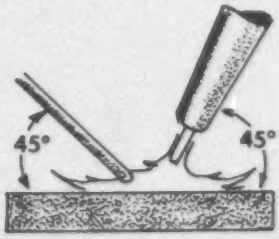
TORCH & ROD MOVEMENT



REINFORCING THIN METAL

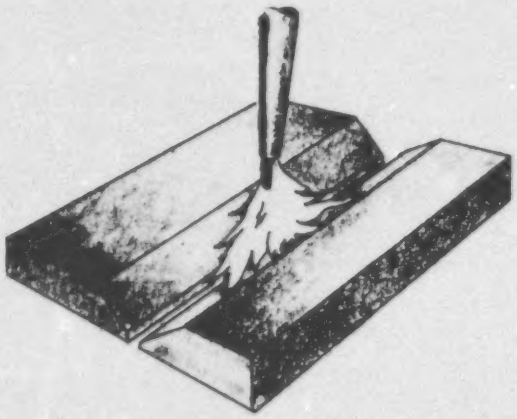


DISTANCE OF CONE FROM METAL

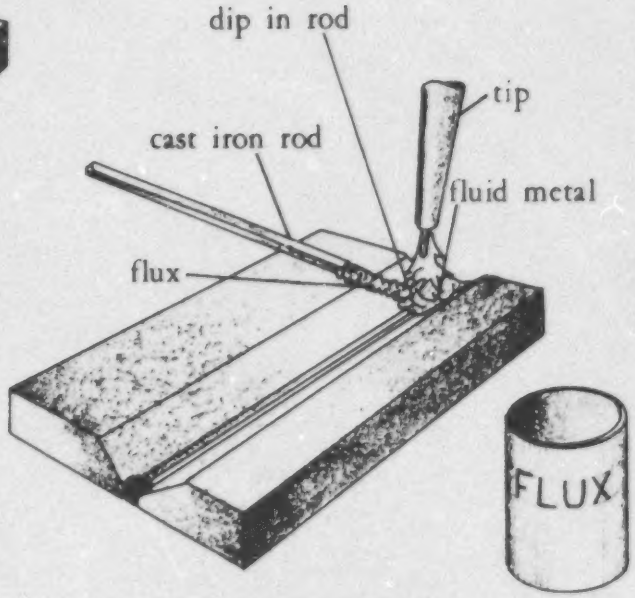


ROD IN OUTER FLAME

WELDING CAST IRON

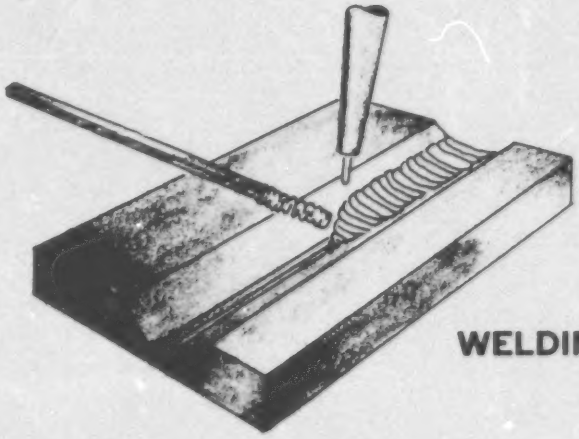


PREHEAT CAST IRON



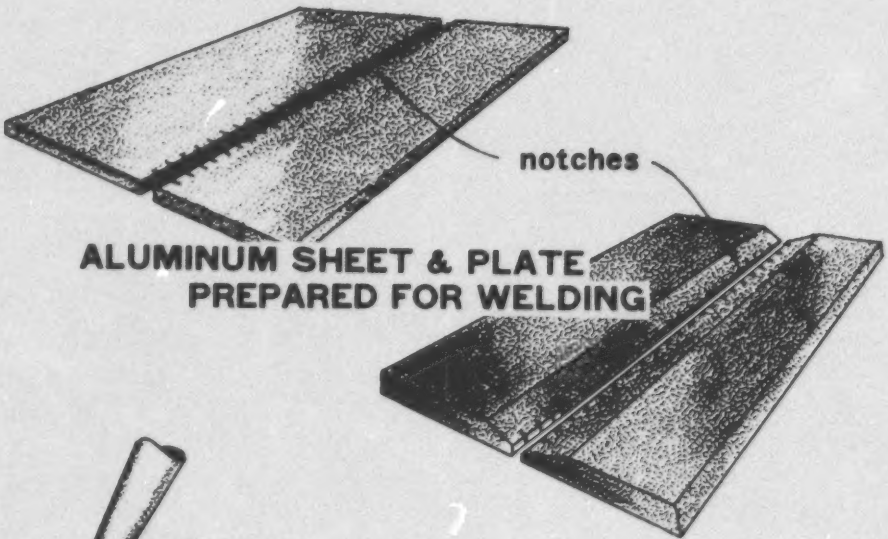
BEGINNING WELD

MULTIPLE PASS WELD

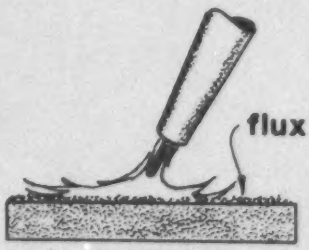


WELDING FIRST PASS

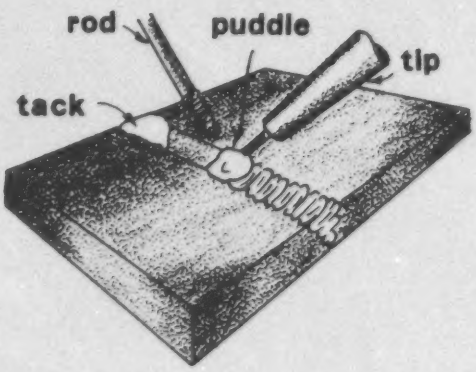
ALUMINUM AND BRONZE



ALUMINUM SHEET & PLATE PREPARED FOR WELDING

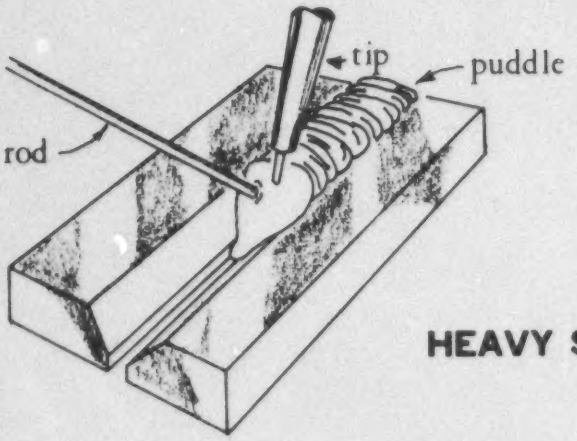


MELTING FLUX ON ALUMINUM

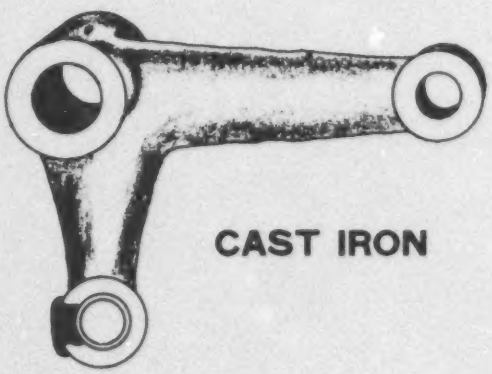


BRONZE WELDING SHEET STEEL

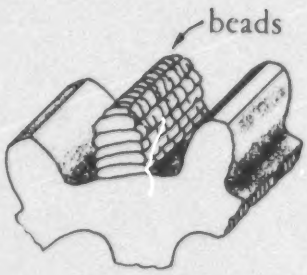
BRONZE WELDING



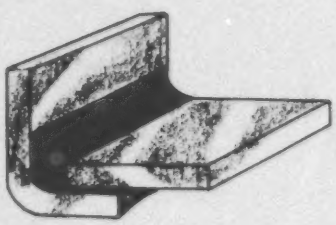
HEAVY STEEL



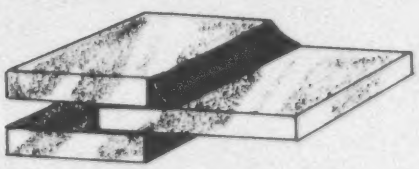
CAST IRON



TOOTH IN GEAR



FLANGED BOTTOM



DOUBLE LAP

HOT METAL WORK

Unit B: Arc Welding

Topic 1 : Fundamentals and Safety

Suggested Procedures and Activities: A demonstration of fusing two pieces of paraffin or ice together by melting their surfaces will be helpful in explaining basic principles of arc welding. The use of welding equipment and supplies will also be helpful while discussing the subject.

1. General Information

a. Arc welding dates back to the latter part of the nineteenth century. The arc, struck between the electrode and the metal, heats the metal to a melting point, then the electrode is removed to break the arc and allow the metal to freeze or solidify. This flame (arc) of intense heat is generated as the electric current passes through a highly resistant air gap. The air gap is the space between the lower tip of the electrode and the base metal.

Transparency No. 1

b. Arc welding may be defined as the process of fusing two or more pieces of metal together by using the heat produced from an electric arc welding machine. Another way the term may be used - metals are fused together by an electric arc generated between an electrode and base metals.

(1) Demonstration: Melt two ice cubes together with a match. When the match is removed the ice solidifies and freezes.

c. Shielded metal - arc welding is another term used to identify the arc welding process. The coated electrode produces a gas which shields the arc from the atmosphere as the electrode melts. Both the Tig (gas tungsten - arc welding) and the Mig (gas metal - arc welding) yield a gas that protects the welding area from the atmosphere.

d. Advantages of arc welding equipment in the agriculture mechanics shop are:

(1) Scrap metal can be used to make and repair many useful items for home and farm use.

(2) Repairs can be made rapidly on farm machinery and equipment, which is good insurance during harvest time and many other critical periods.

(3) Major cracks or breaks can be repaired on machinery and equipment before they cause a major repair problem.

(4) Metal repair and construction jobs may be accomplished more economically with an arc welder than with other types of metal repair and construction equipment.

(5) An arc welder can be used for jobs that require cutting, piercing, gouging, and beveling metal.

2. Types of Arc Welding Machines

Transparencies Nos. 2, 3, and 4

a. An AC (alternating current) welder is the most common type for general agriculture use. Alternating current reverses or alternates its direction of flow (polarity) at the rate of 60 times per second. The AC welder is usually a 180-ampere or 225-ampere unit and performs best where the power supply is between 220 and 240 volts.

(1) Advantages of using 180-225 amp AC welders are:

(a) They can handle most agricultural jobs.
(b) The initial and maintenance costs are relatively low.
(c) A 180 amp AC welder has a "limited input" of no more than 37.5 amperes on a 230 volt single-phase circuit.
(d) The 225 amp welder, being somewhat larger, can handle electrodes one size larger than the 180 amp machine.
(e) The arc blow is not as great in an AC as in a DC machine.

b. DC (direct current) welders are generator-type welding machines that are powered by electric motors, gasoline engines, or other power sources. Direct current flows steadily and constantly in one direction.

(1) Advantages of using DC welders are:

(a) Portable models, powered by engines, can be mounted on trucks or trailers and taken to the work.
(b) Electric power is not necessary for a gasoline powered

welder; therefore, they can be used as mobile units for repair work on construction.

(2) DC welders produce direct current of both straight (negative) and reverse (positive) polarity. Polarity is the direction in which the current flows across the arc.

(a) Straight polarity is when the electrode is negative and the work is positive.
(b) When the electrode is positive and the work is negative, the adjustment is reverse polarity.
(c) Cast iron, thin metal, aluminum, and bronze are welded with a reverse polarity adjustment. Mild steel is welded with a straight polarity adjustment.

c. AC/DC welders are essentially welders equipped with a rectifier (an electronic device to convert AC to DC). If the rectifier is not operating, the welder is an AC type.

(1) Advantages of the AC/DC machine are:

(a) With the rectifier operating, direct current is produced.
(b) This unit is less expensive than the DC machine.
(c) This unit is quieter operating than the DC machine.

d. Tig (tungsten inert gas) welding units consist of an electric power unit; pressure reducing regulator; torch or electrode holder containing tungsten electrode, nozzle, and gas passages; torch cable; welding cable; water and gas hoses; and gas supply unit. The Tig process is either helium or argon. Gas is measured and purchased by the cubic foot.

(1) Advantages of a Tig welding unit are:

(a) Welds are free of corrosive residue. This is due mainly to no flux being used. There is no contamination of oxygen and nitrogen due to the inert gas keeping air away.
(b) The weld is usually stronger and freer of corrosion than in other forms of welding. The inert gas will not combine with elements that cause the metal to be impure.
(c) The weld is free of fumes and slag. This makes it easy to observe the process while welding.
(d) Stresses are reduced due to the heat concentration in a small area, so there is little distortion near the weld.
(e) There is no splatter in this process, which means that no metal is transferred across the arc.

(f) Almost all metals and alloys can be welded by this process.

(2) The nonconsumable tungsten electrode forms the arc to fuse the base metal with or without the use of a filler rod. Tig welding units can be either AC or DC. This type of arc welding is used extensively to weld aluminum and stainless steel.

e. Mig (metallic inert gas) welders are an extension of Tig welders. These types of welders are different from Tig units in that a consumable electrode is used. The electrode is in the form of a thin wire which is usually fed through the torch automatically. Mig units are made up of a welding machine, wire drive and wheel, gas supply, contractor, gun, hoses, current cable (wire), and control unit for wire drive, current, gas flow, and cooling water in part of the unit.

(1) Advantages of using a Mig unit are:

(a) The Mig unit is used in industry as an automatic welder (gun is placed in a variable speed carriage).
(b) Welds can be made by using an electrode with a flux core in the gun.
(c) Other advantages are the same as the Tig unit. However, there is a slag cover on the weld when using a flux cored wire.

(2) Mig welders may be operated by hand. This operation is a semi-automatic system of welding.

f. Other types of arc welding processes include laser welding, submerged arc welding, cybertig welding, and electroslag welding. The most commonly used type of arc welding is still the use of a coated stick electrode that shields the weld puddle from the air. Burning chemical compounds form a blanket of smoke and gas around and over the molten pool of metal.

3. Selecting a Welder and Other Equipment

a. Select a welder that is made by a reliable manufacturer and sold by a reliable dealer.

b. The dealer should be able to give prompt service when needed. The dealer should have an adequate supply of protective equipment, electrodes, and operational information.

c. Check the guarantee on different machines as well as price when comparing

welders of equal capacity.

d. Be sure 230-240 volt service is available for optimum performance. Check the duty cycle of the welder and determine if it meets the needs of the work to be done. Duty cycle is the ratio of arc time to total time (example: 20% duty cycle would be 2 minutes of continuous use out of 10 minutes).

e. The arc welder is usually equipped with ground and electrode cables. The cables are fitted with a ground clamp and an electrode holder.

Transparency No. 5

f. Additional welding equipment is as follows:

(1) Welding helmet with proper cover glass and filter lens

(2) Blacksmith tongs and pliers

(3) Gauntlet type leather gloves

(4) Chipping hammer and wire brush

(5) Welding table and stool

(6) C-clamps, safety glasses or goggles, water can, and soapstone

(7) Welding booth or portable screen

(8) Power grinder

(9) Anvil and ball peen hammer

g. Be sure that equipment is properly installed and maintained.

4. Safety Practices to Observe When Using the Arc Welder

a. Electrical Shock

(1) Be sure the welder is properly grounded.

(2) Secure the services of a competent electrician when making an electrical installation.

(3) Do not run machinery over welding cables. Protect the cables from hot objects and sharp edges.

(4) Do not stand on wet surfaces when welding.

(5) Use only electrode holders that are well insulated.

(6) Wear leather gloves.

b. Radiant Energy - Highly concentrated ultra-violet rays are transmitted during the arc welding process.

(1) Examine the helmet and lens for cracks that would let light in.

(2) Wear protective clothing such as high top shoes, long sleeves, buttoned collars, cuffless pants, and welding gloves.

(3) Cover the face and eyes with a shield or helmet before striking an arc.

(4) Give the word "cover" to all people standing by before striking an arc.

c. Burns - The burns received when welding are a result of coming in contact with hot metal, electrode, particles of spatter, or slag.

(1) Wear eye protection against flying particles of slag.

(2) Use pliers or metal tongs when handling hot metal.

(3) Dress properly.

d. Gases and Fumes

(1) Welding should be done in a well ventilated shop.

(2) An extra fan may be needed when welding galvanized metal.

e. Combustible Materials

(1) Do not weld on containers which have held combustible materials until proper precautions have been taken.

(2) Do not weld near combustible materials such as fuel oils, cleaners,

rags, or trash paper.

(3) Properly dispose of hot electrode stubs.

f. Miscellaneous Safety Rules

(1) Do not lay the electrode holder on the welding table.

(2) Do not stand on grounded metal.

(3) Keep work area clean to avoid falling.

(4) Keep tools and equipment in a safe place so they will not fall on the operator.

(5) Do not hold the electrode holder between the knees or under the arm.

(6) If the electrode sticks and cannot be twisted free, cut off the machine; allow the electrode to cool and break it loose with pliers.

(7) Do not cool electrode holder in water.

(8) Cover eyes when chipping slag. Never rub the eyes if foreign particles get in them.

5. Arc Welding Fundamentals

a. Body Position - It is impossible to get in a comfortable position on most welding jobs; however, the welder should be as relaxed and braced as possible.

b. Correct Electrode Size - Choosing the correct electrode size involves consideration of a variety of factors; such as the type, position, and preparation of the joint, deposition efficiency, and requirements as to weld quality.

c. Correct Electrode Type - Choosing the correct electrode type depends upon the type of base metal to be welded and the type of current available (AC or DC).

d. Correct Amperage Setting - If the current is too high, the electrode melts too fast and the molten pool is large and irregular. If the current is too low, there is not enough heat to melt the base metal and the molten

pool will be too small, will pile up, and look irregular.

e. Correct Arc Length - If the arc is too long, the metal melts off the electrode in large globules which wobble from side to side as the arc wavers, giving a wide, spattered, and irregular bead with poor fusion between original metal and deposited metal.

Transparency No. 6

If the arc is too short, there is not enough heat to melt the base metal properly and the electrode quite often sticks to the work, giving a high, uneven bead, having irregular ripples with poor fusion and slag and gas holes. Correct length is equal to the diameter of the base end of the electrode.

f. Correct Travel Speed - When advancement speed is too fast, the puddle does not last long enough and impurities and gas are locked in. The bead will be narrow and the ripples pointed. When speed is too slow, the metal piles up, the bead is high and wide, and the ripple is straight.

Transparency No. 6

g. Correct Electrode Angle - When making a flat pad weld the correct angle should be 15 degrees from 90 degrees in the direction of travel. Hold the electrode perpendicular to the base metal.

The electrode angle is of particular importance in fillet welding and deep groove welding. Generally speaking, when making a fillet weld, the electrode should be held so that it bisects the angle between the plates and is perpendicular to the line of the weld.

h. Preparation of the Work - Careful preparation of the work is an important part of making good arc-welded joints. Stronger, better-appearing welds are made in less time and with fewer electrodes when the metal has been properly prepared. Preparation can be done with metal saws, a torch, a grinder, or by filing.

6. Types and Uses of Electrodes

a. An electrode is a core wire that can be bare or covered with flux. Flux is a fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides, or other undesirable inclusions formed in welding.

The flux floats out impurities and protects the weld as it settles as slag on top of the weld. The slag is beneficial to certain types of welds because it holds the heat and keeps the weld from cooling too fast.

b. Coated Electrode - The core wire should have the same properties as that of the base metal to be welded. The flux coating is coded for its properties.

c. Bare Electrode - The bare rod usually requires an excessive amount of heat (10,000 degrees F.) as it passes across the arc. This rod is extremely sensitive to voltage change and electrode angle. It is smoke free and makes the weld visible at all times.

d. Carbon Electrode - This type of electrode melts slowly while supplying a stable arc. This is for special purpose welding.

e. Electrode Uses - Electrodes should be purchased according to the base metal to be welded or job to be done. The following metals or jobs to be done determine the composition and use of electrodes: mild steel, alloy, high-carbon steel, cast iron, and hard surface.

7. Electrode Classification and Selection

All major manufacturers of welding electrodes use the American Welding Society (AWS) and the American Society for Testing Materials (ASTM) code of specifications. Each company makes basically the same quality which is established by the AWS. Most manufacturers use the AWS system of numbering each electrode. The National Electrical Manufacturer's Association (NEMA) color code system of identifying electrodes is still used to some extent. These color markings should not be confused with trademarks of the manufacturer. Electrodes are classified according to type of coating, composition of the weld metal, and operating characteristics.

Transparency No. 7

a. Electrodes may be identified in the following manner:

(1) End color marking

(2) Spot color marking

(3) Group color marking

(4) Manufacturer's identification

AWS Class	Color Code	Trade Name and/or Number	Polarity
E6010	None	Lincoln 5	DC Reverse (+)
E6011	Blue Spot	Hobart 335A	AC, or DC Reverse (+)
E6011	Blue Spot	Marquette 130	AC, or DC Reverse (+)
E6011	Blue Spot	Lincoln 180	AC, or DC Reverse (+)
E6012	White Spot	Marquette 120	AC, or DC Straight (-)
E6013	Brown Spot	Airco 90	AC, or DC Straight (-)
E6013	Brown Spot	Lincoln 37	AC, or DC Straight (-)
E6014	Black End	A. O. Smith SW15	AC, or DC Straight (-)
E6018	Black End Orange Spot Green Group	Hobart LH718	AC, or DC Reverse (+)

b. The meaning of the AWS Number (example: E6013)

E - Electrode
60 - The tensile strength of the electrode metal (60,000 psi).
1 - Can be used in all welding positions. If the third number is a 2, it can be used for flat and horizontal welding, but 3 means flat only.
3 - Chemical analysis of the flux (titania potassium), polarity, and current (AC or DC), or the penetrating capacity of the electrode. The fourth digit may range from 0 to 8, each number having a specific meaning.

c. Size of the electrode

(1) The size of the electrode is determined by the diameter of the bare end of the rod.

(2) Specifications for electrodes are as follows: (example E6013)

Standard Size Diameter of Core Wire	Number of Electrodes Per Pound	Standard Length	Amperage Range Setting
1/16 inch	53	18"	20 - 40
3/32 inch	36	12"	30 - 80
1/8 inch	17	14"	70 - 120
5/32 inch	11	14"	120 - 170
3/16 inch	8	14"	140 - 240

d. Electrode use

Electrode No.	Use
E6010	Used to weld mild steel on DC+. Deep penetration and rapid solidification.
E6011	Same as E6010 except can be used AC.
E6012	Use either AC or DC. The penetration is medium.
E6013	Used either AC or DC. Medium penetration, medium slag, and quiet arc. A good general purpose electrode.
E7018	Used AC or DC+. This electrode is used on high carbon steel which is considered hard to weld. It has an iron powder coating.

e. Selecting the correct electrode

Transparency No. 8

Picking the right electrode is a matter of analyzing the conditions applying to a particular job and then determining the type and size of electrode best suited to those conditions. Such analysis is made easier if the operator makes a practice of checking the following factors:

(1) Identification of base metal (mild steel, cast iron, alloy, high carbon)

(2) Welding current available (AC or DC)

(3) Thickness and shape of base metal

(4) Joint design and fitup

(5) Welding position

(6) Job specifications and service conditions

(7) Deposition rate in relation to production efficiency

(8) Environmental job conditions

(9) Electrode storage (moisture causes damage)

References :

1. Althouse, Andrew D., Modern Welding, The Goodheart - Willcox Company, Inc., South Holland, Illinois, 1976

2. Griffin, Ivan H., and Edward M. Roden, Welding Processes, Delmar Publishers, Albany, New York, 1970

3. Morford, V. J., and others, Metals and Welding in Agriculture, Hobar Publications, Division of Hobar Enterprises, Inc., St. Paul, Minnesota, 1970

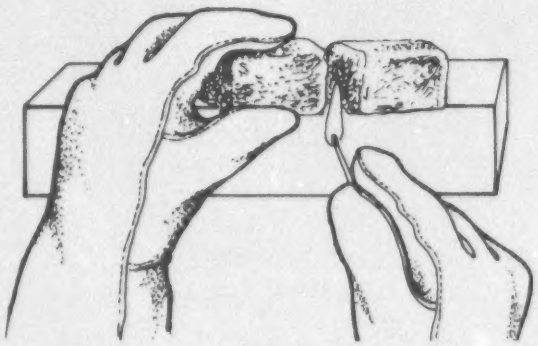
4. "Shielded Metal - Arc Welding", Vocational Agriculture Services, University of Illinois, Urbana, Illinois, 1972

5. "Fundamentals of Service Welding", Deere and Company, Moline, Illinois, 1974

6. "Arc Weld It ... Yourself", Sears, Roebuck and Company, Chicago, Illinois, 1973

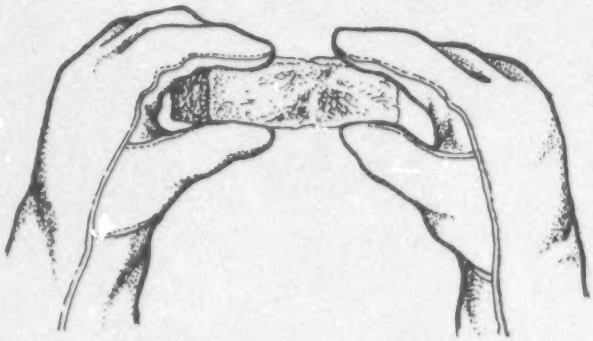
ARC WELDING PRINCIPLES

HEAT WILL CAUSE SURFACE MELTING



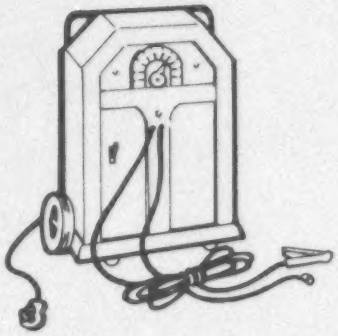
Place two cubes of ice close together & apply heat from a match

REMOVE HEAT SOURCE



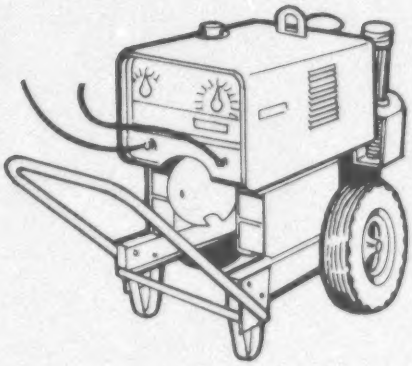
Push the two cubes together. The heat will be drawn out & the cubes will become fused together.

TYPES OF ARC WELDING MACHINES



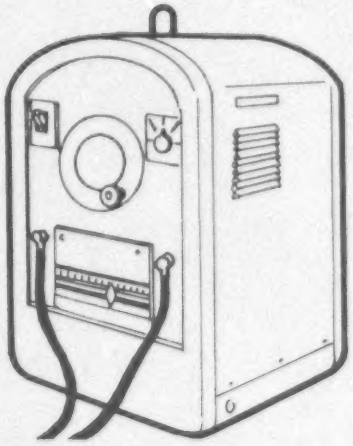
ALTERNATING CURRENT WELDER

(transformer type)



DIRECT CURRENT WELDER

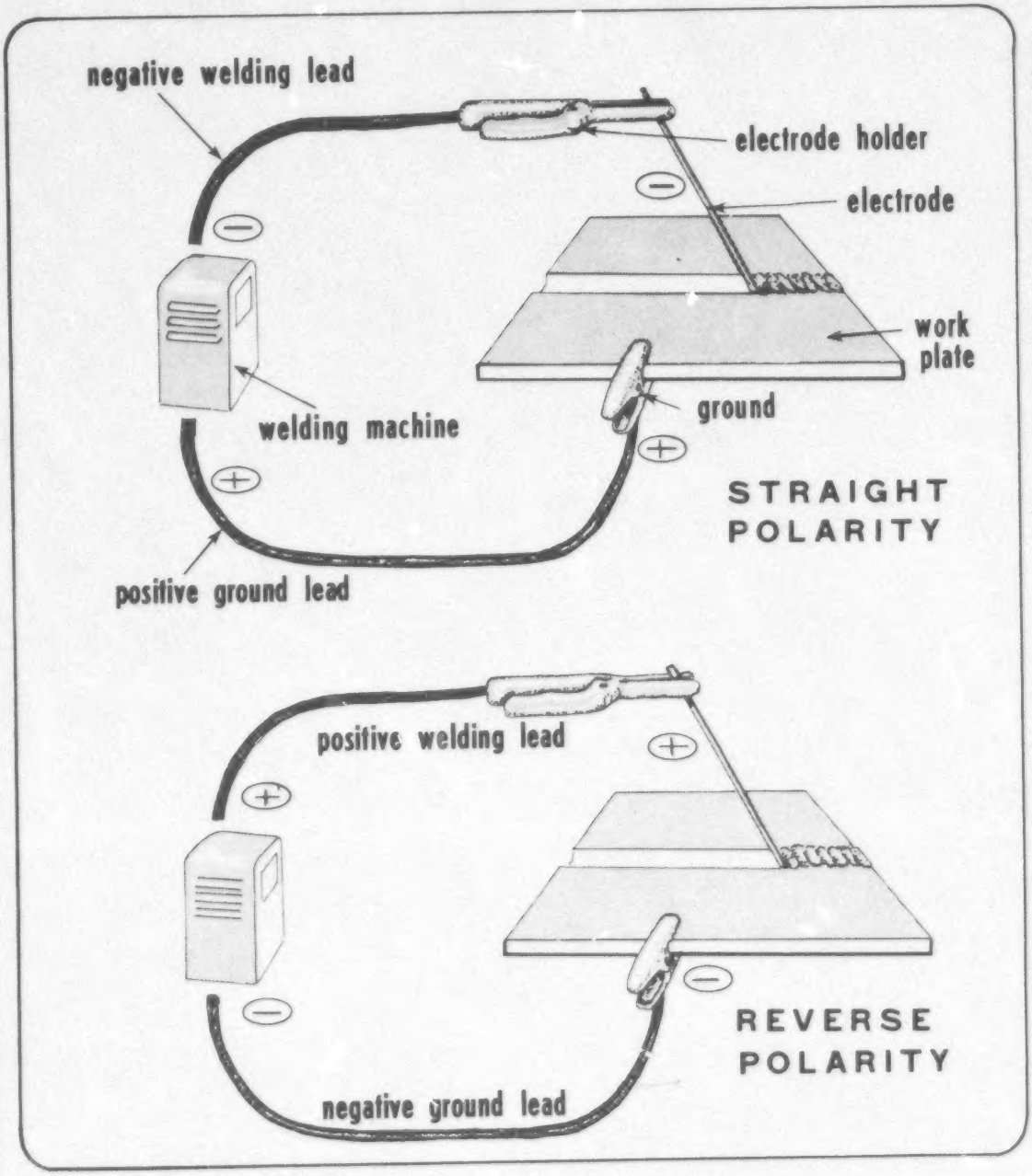
(generator type with gasoline engine)



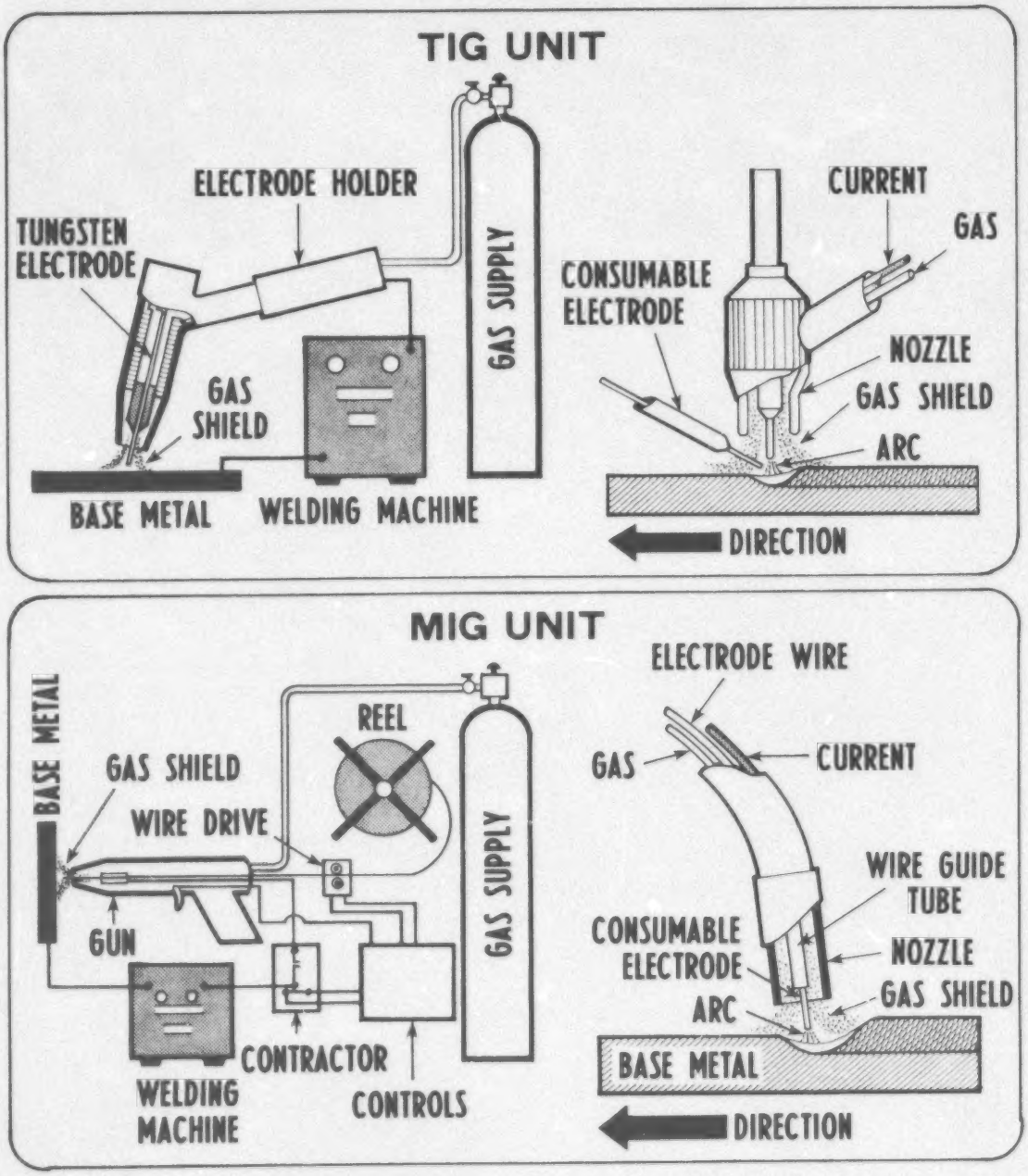
AC/DC WELDER

(with rectifier)

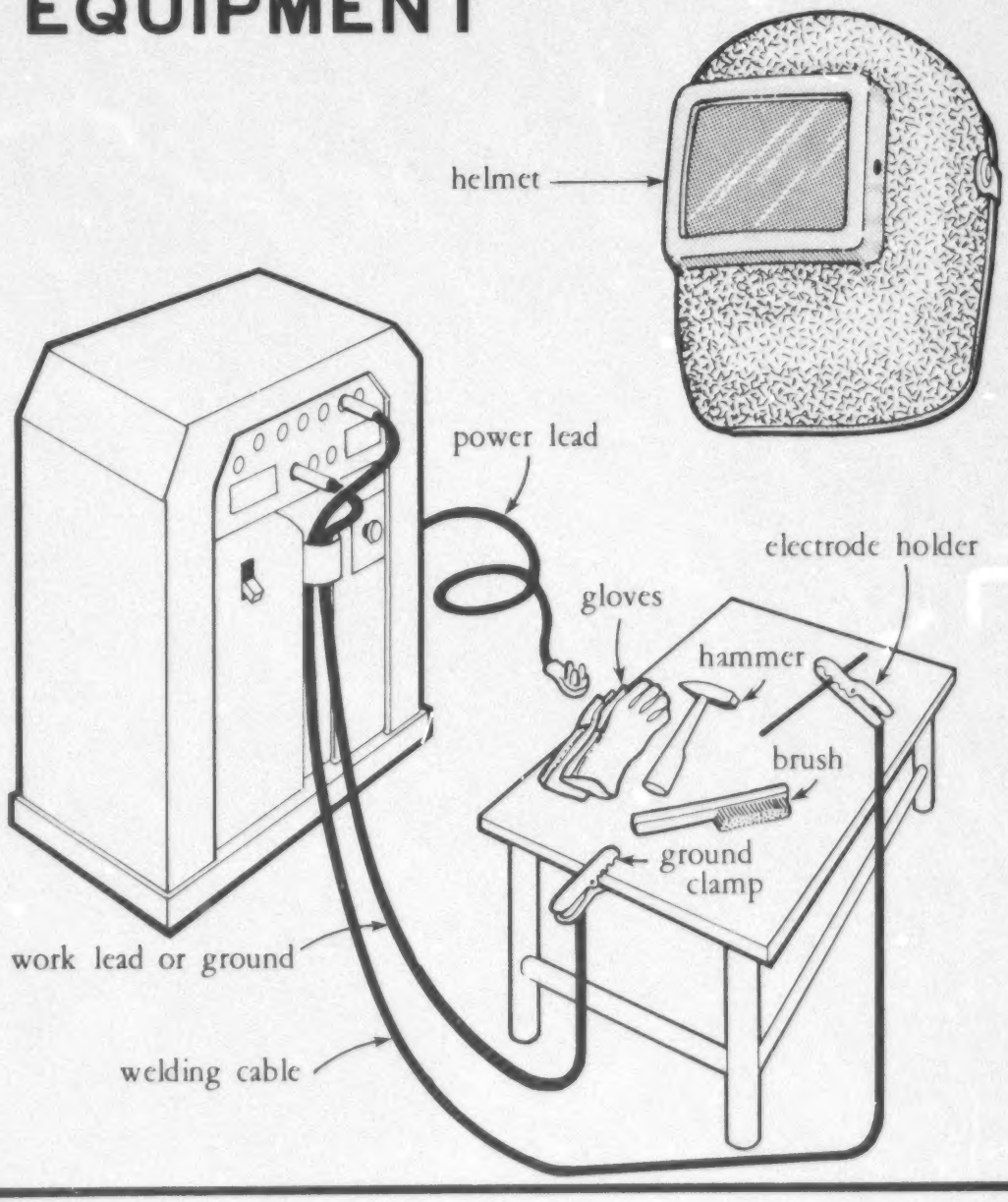
D C ARC WELDING ADJUSTMENTS



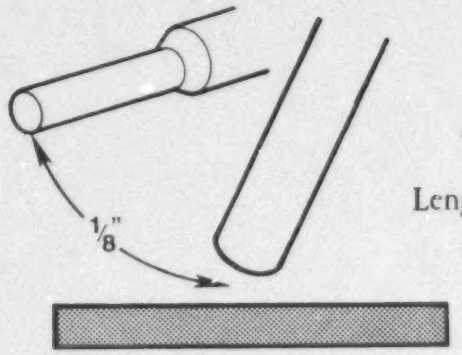
TIG AND MIG WELDING UNITS



AC ARC WELDING MACHINE & EQUIPMENT



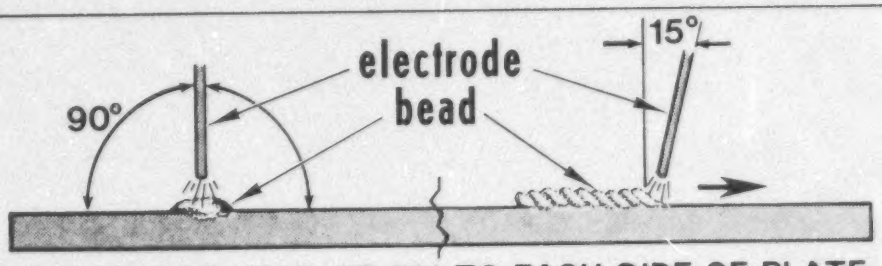
ARC WELDING PRINCIPLES



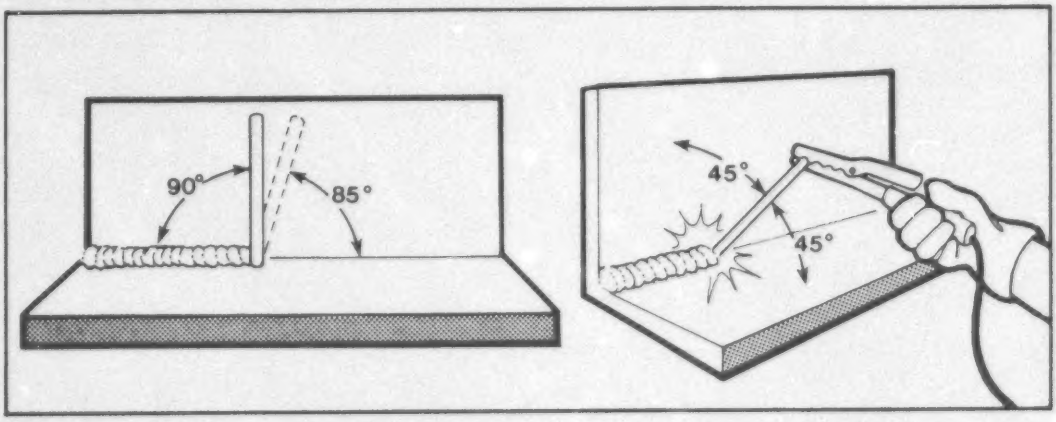
ARC LENGTH

Length should be approximately 1/8" for 1/8" electrode

CORRECT ELECTRODE ANGLE

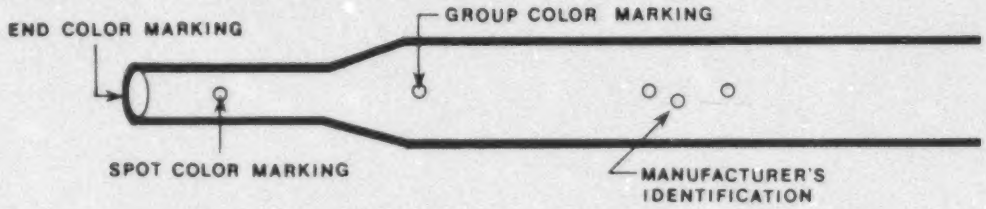


ELECTRODE HELD AT 90° TO EACH SIDE OF PLATE AND 15° IN DIRECTION OF TRAVEL

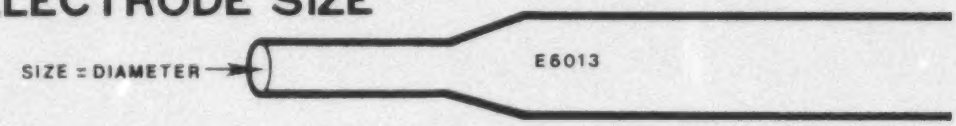


ARC WELDING ELECTRODES

ELECTRODE IDENTIFICATION

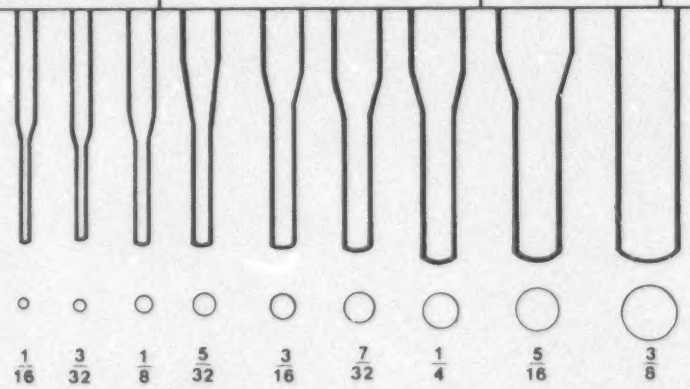


ELECTRODE SIZE

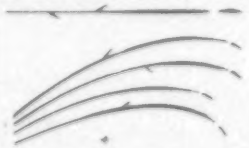
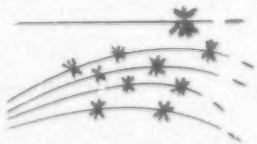


SPECIFICATIONS FOR E 6013 ELECTRODES

Standard Size Diameter of Core Wire	Number of Electrodes Per Pound	Standard Length	Amperage Range Setting
1/16 inch	53	18"	20 - 40
3/32 inch	36	12"	30 - 80
1/8 inch	17	14"	70 - 120
5/32 inch	11	14"	120 - 170
3/16 inch	8	14"	140 - 240



METAL IDENTIFICATION

TEST \ METAL	LOW CARBON STEEL	STAINLESS STEEL	CAST IRON	HIGH CARBON STEEL
appearance	DARK GREY	BRIGHT, SILVERY SMOOTH	DULL GREY EVIDENCE OF SAND MOLD	DARK GREY
magnetic	STRONGLY MAGNETIC	DEPENDS ON EXACT ANALYSIS	STRONGLY MAGNETIC	STRONGLY MAGNETIC
chisel	CONTINUOUS CHIP SMOOTH EDGES CHIPS EASILY	CONTINUOUS CHIP SMOOTH BRIGHT COLOR	SMALL CHIPS ABOUT 1/8 in. NOT EASY TO CHIP, BRITTLE	HARD TO CHIP CAN BE CONTINUOUS
fracture	BRIGHT GREY	DEPENDS ON TYPE BRIGHT	BRITTLE	VERY LIGHT GREY
flame	MELTS FAST BECOMES BRIGHT RED BEFORE MELTING	MELTS FAST BECOMES BRIGHT RED BEFORE MELTING	MELTS SLOWLY BECOMES DULL RED BEFORE MELTING	MELTS FAST BECOMES BRIGHT RED BEFORE MELTING
spark	 Long Yellow Carrier Lines (Approx. .20% carbon or below)	1. Nickel-Black Shape close to wheel. 2. Moly-Short Arrow Shape Tongue (only). 3. Vanadium-Long Spearpoint Tongue (only).	Red Carrier Lines (Very little carbon exists)	 Yellow Lines Bright Burst Very Clear Numerous Star Burst (Approx. .45% carbon and above)

*For best results, use at least 5,000 surface feet per minute on grinding equipment. $\frac{\text{Cir.} \times \text{R.P.M.}}{12}$ = S. F. per Min.

HOT METAL WORK

Unit B: Arc Welding

Topic 2: Procedures

Suggested Procedures and Activities: Welding machines, equipment, and supplies may be shown during discussion. Demonstrations by the instructor followed-up by student practice and assignments will acquaint the student with arc welding procedures.

1. Metal Preparation

Transparency No. 1

a. Metal should be thoroughly cleaned before it is welded. Stronger, cleaner, and better-appearing welds are made in less time if the metal is properly prepared. Also, fewer electrodes are used to weld clean metal than are used to weld rusty, unprepared metal.

b. An additional 20 amperes is required to weld rusty or greasy metal than is required to weld clean metal.

c. Metal may be cleaned by brushing, filing, grinding, and scraping. Grinding is considered the best way to clean metal.

d. Proper preparation of the stock is as follows:

(1) If the pieces of metal are less than 1/4 inch thick, the surfaces may be ground to remove the casting skin.

(2) Stock that is more than 1/4 inch thick should be beveled at a 30-degree angle. The two pieces of metal placed with the beveled edges together will form a 60-degree angle.

(3) If stock is beveled on one side or both sides, the unground surface should be 1/16 to 3/32 of an inch thick.

(4) Metal pieces that are over 1/4 inch thick should be spaced 1/32 to 1/16 inch apart before welding.

2. Amperage Adjustment and Welding Position

Transparencies Nos. 2 and 3

a. After the electrode is selected, the welding machine amperage should be set to get a good penetration with a minimum of spatter. The amperage setting is determined by thickness of the metal to be welded, the size of the electrode, the speed of travel, and position of the weld.

b. If the amperage is too high, the bead will be flat and porous; and the edges will be spattered. If the amperage is too low, the metal will pile up making a high, narrow bead. A bead, welded with low amperage, will not have the proper penetration.

c. The approximate amperage, size of electrode, and thickness of metal is given below:

Suggested Amperage Setting

Approximate	Size of Electrode	Thickness of Metal
65	3/32"	1/16"
80 - 100	3/32"	3/32"
80 - 100	1/8"	1/8"
115 - 130	5/32"	3/16"
130 - 150	5/32"	1/4"
140 - 150	5/32"	5/16"
160 - 175	5/32"	3/8"
175 - 200	5/32"	1/2"

Alternating current (AC) is different than direct current (DC); in that there is no polarity adjustment to make for welding. The alternating welding current reverses many times per second while the welder is being used.

d. Correct welding positions (a left-handed person should reverse the procedure) include:

(1) Sit or stand in a relaxed position to avoid fatigue.

(2) Hold the electrode holder in the right hand. Place the left hand on the underside of the right hand.

(3) If in a sitting position, put the left elbow on the left knee. This

position braces the body, yet it still permits free movement.

(4) Hold the electrode holder firmly and weld with both hands, if possible.

(5) The movement of the electrode should be from left to right.

(6) The position of the electrode should be in line with the weld and leaning at about a 15-degree angle to the metal or in the direction of travel.

3. Starting the Arc

Transparency No. 4

a. An arc is formed in a circuit when the electrode is brought in contact with the metal surface and then withdrawn slightly. The current jumps this gap and makes an arc hot enough to melt the metal surface and the electrode.

b. Two methods of striking an arc are as follows:

(1) Tapping method

(a) Set the welding machine to the correct current.
(b) Bring the tip of the electrode straight down and tap it on the metal surface.
(c) After striking the arc, hold the electrode tip between 1/8 and 1/4 inch above the stock to allow the arc to become established before starting the weld. Begin welding with the tip 1/8 inch above the bottom of the crater.
(d) Tilt the electrode about 20-degrees from vertical in the direction of travel to make the weld.

(2) Scratching method

(a) Set the welding machine to the correct current.
(b) Bring the tip of the electrode down in a sweeping motion (the motion for striking a match).
(c) Raise the electrode 1/8 inch at the end of the sweeping motion.
(d) As the molten crater forms, maintain the 1/8 inch distance between the tip and the bottom of the crater.
(e) Tilt the electrode 15-degrees for making the weld.

c. The correct arc length may also be determined by sound. When the arc is too long, it will give off a bellowing sound. If the arc length and amperage are correct, the arc will give off a continuous crackling or frying sound. A very short arc will produce a muffled popping sound.

d. The correct arc length will eliminate excessive spattering, overlapping, and undercutting. It will give fairly deep penetration with the proper fusion of metals.

e. If the electrode sticks to the plate or stock, it should be broken loose with a quick twisting or bending motion. If it becomes welded to the plate, disengage the holder and break it loose with pliers.

f. Causes of difficulties in starting an arc:

(1) Flux coating is chipped on the electrode tip. A fast scratching method and finishing the sweep with a long arc is the best way to strike an arc.

(2) The work is improperly grounded. Arcing may occur where ground clamp is attached to the metal. Metal should be clean where clamp is attached.

(3) Improper electrode contact in the holder jaws. The holder may have a weak spring, foreign material in the jaws, or the jaws may be holding the electrode by the flux coating.

(4) Failure to use the correct electrode for the recommended amperes or metal stock.

(5) Loose connections between the cables and welder terminals. Loose and dirty connections may reduce the electrical efficiency of the welder.

4. Steps in Laying a Bead

Transparencies Nos. 5 and 6

a. Before laying a bead, the welding machine should be adjusted to the proper amperage. For example, a 1/4 inch plate can be welded with an 1/8 inch or larger electrode at an amperage setting between 80 and 110; but if a 3/8 inch plate is welded, more heat is needed to bring the metal up to a molten stage. A 5/32 inch electrode and an amperage setting of

160 is recommended to weld a 3/8 inch plate. Another way to adjust the amperage setting is set the current to correspond to the diameter of the rod. The measurement is in thousandths of an inch and only includes the metal part of the electrode. Example: A 1/8 rod measures .125; therefore, the machine will be set to operate at about 125 amperes + or -. A 5/32 inch electrode measures .156 inch so the amperage setting should be 150 plus or minus a few amperes.

b. The second most important step is to hold a long arc until the base metal begins to melt, and continue to watch the puddle instead of watching the arc.

c. After the metal begins melting, the electrode should be brought down to form the proper arc length and the top slanted toward the line of weld for running a bead.

d. Maintaining a good puddle is one of the most important steps in making a good weld. The puddle should be about 1 1/2 times as wide as the width of the electrode. The slag should not flow in front of the puddle.

e. In order to maintain a good puddle, the speed of travel must be adjusted to permit a desired bead height. Usually, welding a heavy plate requires a slower speed than welding a thin plate.

f. If the arc is broken while running a bead, it should not be started in the same place (the crater of the interrupted bead). It should be started on the metal ahead of the crater. The weld passes back through the crater toward the bead and then back over the same path in the line of weld.

g. The best way to fill a crater at the end of a bead is to push the end of the electrode down into the crater, almost to the sticking point, and pull it away quickly to break the arc.

h. The electrode movements for laying a weld bead are:

(1) The two main movements are the downward feeding of the electrode to maintain the desired length and the movement along the weld line.

(2) Crescent weaves are used to strengthen welds by making a better quality of weld. The most common types of crescent weaves are:

(a) Back-and-forth motion with a slight arch (easiest to use

for inexperienced welders).

(b) Back-and-forth motion with a slight arch and a V at the end to work the metal into the edges.

(c) Back-and-forth motion with semicircular round ends; used for vertical and overhead welding.

(3) Circular weave is used for vertical and overhead welding.

(4) The straight back-and-forth weave is used mainly for flat surface welding. A "V" or leaning N is formed in this weave.

(5) The whipping weave is used by the more experienced welder. This type of weld permits a deeper penetration and allows gas and slag to surface.

5. Padding or Building Up and Weaving

Transparency No. 7

Weaving should not be practiced until the skill of running a bead has been more or less perfected. Padding gives the individual the opportunity to practice running a bead.

a. Padding steps are:

(1) Begin welding a bead in the upper left-hand corner of the plate; maintain the bead longitudinally flush with the upper edge of the plate while moving from left to right.

(2) Both ends of the weld must be flush with the edge of the plate; therefore, the crater should be filled at the end of the bead.

(3) Chip and wirebrush the bead until it is perfectly clean before laying another bead along its side.

(4) Place the second bead so that it will fuse with one-fifth of the first bead.

b. Repeat each padding step until the entire surface of the plate or area is completely covered with deposited metal and is flush on all four sides.

c. The welding operator should learn the different positions for welding under different welding conditions. The arc cannot be moved from left to right at all times. The other three positions include:

(1) Without changing the position of the practice plate, begin at the lower left-hand corner and lay the bead away from the body. Use steps 2, 3, and 4 for padding. Cover the entire plate and brush clean for the next layer.

(2) Deposit a third layer without moving the plate, but move the arc from right to left. Again, use steps 2, 3, and 4 for padding. Brush all beads clean before starting the fourth layer.

(3) Add the fourth layer with the steel plate in the initial position. Clean the plate so that the beads can be examined.

d. The steps to use for practicing weaving are as follows:

(1) Use a piece of soapstone and mark parallel lines on the plate at 1/2 inch intervals.

(2) Weld beads along the marked lines, spaced at 1/2 inch intervals; chip and brush the beads clean.

(3) If a 1/8 inch electrode is to be used on a 1/4 to 3/8 inch thick plate, the amperage should be raised from 100 to 110 or 115. It takes more heat and a larger puddle for a wide bead than is required for a narrow bead.

(4) With coated electrodes use a flat semicircular motion, hesitating briefly at each side to avoid under cutting.

(5) Fuse the wide bead into the straight bead at 1/5 the width of the straight bead. The height of the wide bead should be uniform in height over the entire plate.

6. Types of Welds and Weld Joints

Transparencies Nos. 8 and 9

a. The two types of joints most commonly used on arc welding are the butt and fillet welds. The following numbers (1) and (2) are butt welds and numbers (3), (4), and (5) are fillet welds:

(1) Square Joints - These joints are unbeveled if the metal is less than 1/4 inch thick, and the two pieces are spaced about 1/2 their thickness apart to permit good penetration.

(2) Single Beveled and Double-Beveled Joints - These joints insure

penetration and fusion of the metals. The pieces are also spaced apart for welding purposes. Metal that is more than 1/4 inch is usually beveled.

(3) Tee Joints - The T joints are made by placing two pieces of metal together to form a T. The two pieces are welded together with one or more passes of a fillet weld.

(4) Lap Joints - One piece of metal is placed over the other, and they are jointed together by welding the ends.

(5) Corner Joints - The corners, forming a groove with a 90-degree angle, are placed together at right angles.

7. Steps Used When Making Butt and Fillet Welds

Transparency No. 10

a. Butt welds in the flat position are most commonly used. Most broken parts of machinery can be repaired by a butt weld. Butt welding steps in the flat position are:

(1) Place two pieces of metal side by side leaving a 1/16 inch space between the two pieces for thin metal and 1/8 inch space for heavy metal.

(2) Tack weld each end of the prepared pieces. Tacking is to prevent warping while the metal is being welded.

(3) If the metal is beveled, start the pass in the groove on the tack weld. Use a very short arc for the first pass. The electrode lead angle can be as much as 45-degrees.

(4) If an unbeveled metal plate is being welded, it should be tacked and a welding pass made from both sides of the plate. A steel strip may be used if the joint cannot be fitted.

(5) The first (root) bead is made without a weaving motion of the electrode. The future passes are made by a crescent weave, but between each pass the prior bead or weld is cleaned before making the next pass.

(6) If a crescent bead is used, the arc must be hesitated on each motion at the edge of the groove in order to build up the edges of the bead.

(7) On the last pass, a weaving motion must be used on heavy metal to obtain a reinforcing cover over the preceding beads.

Transparency No. 11

b. Fillet welds are used to join two surfaces that meet at right angles. Flat fillet welds are very easy to make if the two pieces of metal to be welded form a "V" in the up position. Fillet welding steps in the flat position are:

(1) Place two pieces of plate metal together forming a "T" (upside down); tack both ends of the pieces to prevent distortion.

(2) The electrode may either be placed in the electrode holder at a 45-degree angle, or the electrode may be held at a 45-degree angle from each side of the plates when making a welding pass. The electrode should also be pointed into the joint with a 15-degree lead.

(3) Move the electrode steadily along the seam at a rate that allows the weld puddle to penetrate each piece of metal. A side-to-side motion is not necessary on the first pass. If a 5/32 inch electrode is used, one inch of weld should be laid for each inch of electrode used.

(4) The second pass is made after cleaning the slag from the bead with a wire brush. The second bead should be laid on the flat surface against the first bead. Slag is removed from the second bead.

(5) The third pass is laid on top of the first pass and against the vertical plate. It also penetrates the edge of the second pass. Slag is removed from the third pass.

(6) If it is necessary to lay additional passes, the fourth bead should be laid at the bottom. The fifth and sixth beads should follow to complete the weld.

(7) Welding speed can be increased and undercutting reduced if a "T" joint is welded in a "V" position. The arc should be short and the electrode must be held in the center of the "V" to make a good weld. Weaving may be practiced if more than one bead is laid.

(8) When welding thin metal to heavy metal, the angle of the electrode should be about 60 degrees from the heavier metal.

(9) The bead (s) should be cleaned and checked for uniformity and penetration.

8. Other Position Welding

a. The three different types of position welds are referred to as vertical, horizontal, and overhead. The vertical weld is used more than the other two.

b. The difficulty encountered when making an out-of-position weld is the control over the molten metal in the puddle. The puddled metal has a tendency to fall from the puddle. General practices to follow when making a position weld are:

(1) Use an amperage setting that will permit the highest current possible for handling the thickness of the metal being welded. Usually, lower amperage is used for position welding rather than flat welding. It is necessary to try several amperage settings in order to locate the correct amperage.

(2) The electrode should be placed in the proper position for the weld.

(3) Strike the arc and hold it shorter than is required for flat position welding.

(4) Begin by moving the electrode slowly until the molten metal will no longer remain in the puddle; increase the speed until a desired buildup of metal is obtained. The metal will solidify before dropping off if the correct speed is used.

(5) Use the proper size and type of electrode. AWS No. E6011 electrode is suited for position welding. Electrodes of smaller diameter are easier to control than large diamcter electrodes.

(6) After the bead (s) are laid, they should be cleaned and checked for uniformity, sags, craters, penetration, and width.

Transpa.ncy No. 12

c. Vertical Welding - The two most commonly used methods of vertical welding are "vertical-up" and "vertical-down". The steps for making the welds are:

(1) Light metal is easier to weld than heavy metal. For example, in order to get the "feel" of position welding, use metal 1/8 inch thick and an electrode 8 inches long; set the amperage between 60 to 80.

(2) Place the metal plate in a vertical position and secure before starting

the weld.

(3) Place the electrode in the electrode holder. Position it at an angle of 60 degrees to the plate and in the path of the weld. The electrode should be perpendicular to the sides of the plate.

(4) Begin welding at the top of the plate with a very short arc. If the electrode sticks to the plate, increase the amperage. If a "burn through" is repeated several times, lower the amperage or increase the speed downward.

(5) When welding vertical-up, place the elctrode in the electrode holder so that it may be held at about 90 degrees to the metal in the path of the weld.

(6) Weld thick metal by using one or more side-to-side motion passes.

Transparency No. 13

d. Horizontal Welding - This type of weld is used to butt weld plates or make repairs in the horizontal plane position. The welding steps are:

(1) Secure a plate in a position for running beads in a straight line from left to right.

(2) Place the electrode in the holder so that it can be held at 90 degrees from the plate sides. Lean the top of the electrode slightly toward the area to be welded.

(3) Bevel metal pieces over 1/8 inch thick before welding them together in the horizontal position. Tilt the electrode according to the pass and bevel when welding thick metal.

(4) Adjust the amperage, speed, and length of arc to prevent excessive sagging.

(5) When welding thick metal that has been beveled, more than one bead or a weaving bead should insure a stronger weld.

Transparency No. 14

e. Overhead Welding - Overhead welds are made similar to flat position welds, except they are much more difficult to make than any type of

weld. The major difficulties are to maintain a short uniform arc and protect the body from molten metal. The overhead welding steps are:

(1) Secure the metal plate above the head when in the standing position.

(2) Protect the body by wearing protective clothing. (Heavy jacket with long sleeves and tight collar.)

(3) Place the cable on the shoulder and hold the gloves in a position to prevent sparks from entering them.

(4) Place the electrode in the holder to permit the most comfortable position for welding.

(5) Use a 1/8 inch or 5/32 inch rod, and the same amperage setting that is used for vertical welding. If the electrode sticks, increase the amperage.

(6) Weld with a short arc and a moderately fast rate of travel to prevent sagging and undercutting.

(7) Use a weaving pattern on heavy metal. The weaving motion must be somewhat faster than other position welds.

9. Welding Various Kinds of Metals

a. Cast Iron- This metal is very difficult to weld. It expands, contracts, and even crumbles under certain heating conditions. As the metal cools, cracks may appear in or near the welded area. The two types of electrodes for welding cast iron are:

(1) Nickel or copper - core electrodes are used to weld cast iron to steel. The major purposes of using these types of electrodes are:

(a) The metals are machinable.
(b) The casting (s) do not require preheating.
(c) The cooling speed does not have to be controlled.
(d) The electrode is more expensive than a steel-core electrode; but in nearly all cases, the cost of the weld is less expensive.

(2) Steel-core electrodes are not recommended for malleable cast iron. Preheating and controlled cooling is necessary if steel-core electrodes are used. Also, the weld cannot be machined when using this type of electrode.

b. Sheet Metal - Observe the following practices when welding sheet metal:

(1) Use low amperage and weld as rapidly as possible to prevent burning a hole in the metal.

(2) Use an electrode no larger in diameter than the thickness of the metal.

(3) Use a short arc.

c. High Carbon Steel - High carbon steel becomes brittle if it is cooled very rapidly. Welding practices include:

(1) Preheat the metal to a blue color and maintain this color throughout the weld.

(2) Use a mild steel electrode and lower amperage than is used for welding mild steel.

(3) Allow the metal and welded area to cool slowly.

10. Arc Welder Cutting

Transparency No. 15

a. The arc welder is not a metal cutting machine, but metal can be cut, pierced, or gouged if the proper procedure is used. The electric arc can be used to cut steel, cast iron, and many nonferrous metals. More fumes are produced from cutting than welding; therefore, the cutting area should be well ventilated. Fumes from cutting galvanized metals, lead, brass, bronze, and painted metal can be dangerous if inhaled.

b. Some steps to follow in cutting metal include:

(1) Select a mild steel (E6011) electrode 1/8" to 3/16" and use a welding current at 160 to 180 amperes. Soak the electrode in water for about 10 minutes. An electrode that has lost its coating should not be used.

(2) After arranging a sand pail to catch the molten metal, start the cut at the edge or corner of the base metal. The area to be cut should be extended over the edge of the welding work table. Use the electrode in a similar manner as a chisel; push the electrode up and down and move it slowly along the line to be cut. The upward stroke arc is long to cut the metal and the downward stroke arc

forces the molten metal out.

(3) To pierce rough holes in metal less than 1/4 inch thick, use the following method:

(a) Strike the arc and hold it in one spot until the metal begins to melt. The electrode should be held at a 90-degree angle to the surface for cutting a straight hole.
(b) Push the electrode down at a rapid rate or as rapidly as possible as the metal continues to melt.

(4) Cutting bevels can be accomplished by using the arc welder but a much neater job is realized when using a grinder or oxyacetylene cutting torch. If it is necessary to use the arc welder for beveling, the following steps may be used:

(a) Lean the electrode in the direction of the bevel. The angle between the electrode and metal should be the same angle as found on the finished bevel.
(b) Hold the core of the electrode near the metal and move the electrode in the direction of the cut as the metal is blown from its path of travel.

11. Hard Surfacing

Transparency No. 16

a. Hard surfacing, sometimes called hard facing, is the process of applying a layer of wear-resistant metal to the surface or cutting edge of a part to increase its life.

b. Hard surfacing is mainly used to repair worn edges of farm equipment, such as plowshares, cultivator sweeps, harrow spikes, and planter shovels.

c. The steps for hard surfacing are as follows:

(1) Grind the surface free of rust and scale.

(2) Select an abrasive work-hardening electrode and set amperage between 75 and 100 degrees for a 1/8 inch electrode or 130 to 140 degrees for a 5/32 inch electrode.

(3) Apply the hardening metal in even thin layers by using a weaving

bead no wider than "1 inch".

(4) Remove slag before laying additional beads.

(5) A certain amount of shaping can be done by grinding, but if there is excessive build-up, shape the metal by heating and forging.

(6) The steps in hard surfacing a plowshare are:

(a) Run the beads from the heavy part toward the point on the underside (ground side) and parallel to the cutting edge.
(b) Lean the electrode at about a 30-degree angle with the burning point in the direction of the plowshare point.
(c) Lay weaving beads side-by-side until the cutting surface is covered. The layer must be smooth.
(d) If necessary, peen the deposited weld metal as it cools.

d. The steps for hard surfacing a thin cutting edge are as follows:

(1) Apply hardsurfacing powder in a layer twice as thick as the finished deposit. This powder can be applied dry or as a paste, and it should cover the entire area that needs to be hardened.

(2) Use a carbon arc torch (carbon arc attachment may be used on AC or DC welder) in a circular motion to fuse the powder to the base metal. Carbon arc welding is usually done on a flat surface because the flame cannot be blown into a recessed area.

Transparency No. 17

12. Pipe Welding

Pipe welding is not necessarily a special type of welding. In fact, the same welding procedures are used for making butt and fillet welds on flat plate. It may seem more difficult, but the skill can be successfully mastered after mastering the common welds. It is more difficult to prepare some pipe joints for welding than preparing flat surface metal.

a. Procedure for making different types of pipe joints are as follows:

(1) Ell Joint - Pipe may be marked at a 45-degree angle by using outside even numbers on the tongue and blade of a framing square

or by using a T-bevel square set at a 45-degree angle. Chalk and soapstone serve as good marking tools. The pipe is cut along the line, and finished joints are cut on a grinding wheel.

Butt the joints together and weld from point to heel, after tacking the joints together. If welding is performed from heel to point, the heat will be more difficult to control, which may cause burn-through.

(2) Tee Joint - If the joint is made to carry a liquid, cut a hole in the header pipe and grind the branch pipe to fit the header pipe. The area to be cut on the branch pipe can be marked with chalk or soapstone by placing the branch pipe on the header pipe to make the proper arc. The pipe should be tack-welded in four places. Start weld at the center (high point on arc) and weld toward the 90-degree angle formed by the two pipe pieces.

If the pipe is not used to transfer liquid then it is not necessary to cut a hole in the header pipe or to cut an arc on the branch pipe, but it is necessary to flatten the end of the branch pipe on two sides; tack it to the header pipe and weld.

b. Some suggestions for bending and welding pipe are:

(1) Bend small diameter pipe by using a pipe bender, a bending jig, or two fixed studs. Begin bending at one end and bend slightly every inch or two. To prevent flattening thin walled tubing, fill it with sand and plug the ends. Heavy pipe can be bent if it is heated. Wrinkle bending may be used on pipe over 1 1/2 inches in diameter. Wrinkles will form on the underside of the bend.

(2) If the ends are to be welded either a flat plate can be welded over the end or scallops can be cut, heated, and bent in so they may be welded together.

c. Pipe welding positions are:

Roll Welding - The weld is started one-fourth of the way down from the top of each side of the pipe. The torch tip is pointed upward. This torch position is used in vertical welding. The pipe is rolled one-fourth turn, a second weld is made, and the procedure is continued until the four welds are completed.

Position Welds - The pipe is in a stationary (fixed) position; therefore, the weld is made by beginning at the bottom and moving to the top on each

side of the pipe.

The steps to follow when welding a pipe are:

The opening in pipe smaller than 2 inches in diameter is too small to insure good fusion. It is usually not necessary to bevel small pipe. Three-inch pipe should be beveled and the ends should be spaced apart slightly over 1/8 inch.

Clamp the pipes in position for tack welding. Remove the clamps after the tacks are completed. Small pipe may require three tack welds, whereas large pipe (6 inches or more) may require five tack welds. Tack welds may be made about one inch long.

13. Gas Tungsten Arc Welding (GTA) or Tungsten Inert Gas Welding (Tig)

a. Starting the Unit - Check to see if the gas and water are on (water cooled unit). The control may be in the torch hanger or electrode holder. In some units the flow is controlled automatically. Water flow may vary from 12 to 23 gallons per hour in a water cooled unit. The gas flow (cu. ft./hr.) is determined by the kind and thickness of metal being welded.

b. Electrodes - Tungsten electrodes are of three shapes. The AC electrode has a spherical end, the DC straight polarity (DCSP) a pointed end, and the DC reverse polarity (DCRP) a round or ball end.

c. Striking the Arc - The following method is used for striking an arc:

(1) When using high frequency alternating current, move the torch to the horizontal position over the work or block. Direct the torch to the upright position and the electrode within 1/8 inch of the work. The arc should jump this gap.

(2) If direct current is used, the electrode must touch the work and be withdrawn to the proper distance for welding. To keep the tungsten electrode clean, touch it to a tungsten block.

(3) In order to warm the tungsten torch and make the starting of a weld easy, use a practice piece of metal before starting the actual weld.

(4) Before starting a weld check the electrode extension so that it will extend out of the nozzle a distance equal to the inside diameter of the nozzle except when fillet welding, in which case the electrode should

be longer.

d. Special Welding Instructions - Steel alloys should be at a temperature of 60 degrees F. or more and aluminum 120 degrees F. before welding. Steel cools to about 350 degrees F. and aluminum to 300 degrees F. between welding passes. To protect the penetration side of the weld, four or five spurts of gas should be used; then continue feeding the gas at a steady rate while welding. If cracks appear at the beginning of the weld, remove them by buffing or grinding on the emery and reweld. This condition may also happen at the end of a weld. When welding pipe smaller than 6 inches in diameter, passes can be 3 inches long. Tungsten electrode for AC welding can be cut by first nicking the electrode with a grinding wheel and then breaking with pliers.

e. Making a Weld - Use the following procedure when welding with the tungsten arc welder:

(1) Prepare 60-degree grooves for joints if the metal is thicker than 3/32 inches thick. Welds can be made with no edge preparation. Special precautions should be used to keep out air impurities when welding magnesium and titanium joints. Flange joints should be used by the beginner. The kind of metal being welded determines the type of filler electrode to be used and the type of current needed.

(2) When starting the weld make a small beginning puddle and hold the electrode holder between 60 and 80 degrees to the metal. Use a very small circular motion for starting the puddle.

(3) Move the arc back of the puddle and place the filler rod inside the front part of the puddle; that is, if a filler rod is used. The filler rod should be held almost flat (about 20 degrees) as it is moved in front of the weld.

(4) The weld can usually be stopped in two different ways: by reducing the current with the foot control or lifting the electrode holder to break the arc. The gas should be kept flowing until the tungsten electrode has cooled.

(5) Make horizontal and overhead welds using the procedure as in regular arc welding. When welding in the vertical position, weld downward.

(6) Always use the proper size and type of electrode for the job. If the electrode is entirely too small it may melt back to the collet (inside holder). A large electrode may cause the arc to wander from side

to side.

(7) Weld all metals immediately after cleaning. Dirty metal will cause contamination of the electrode and weld.

14. Gas Metal Arc Welding (GMA) or Metallic Inert Gas Welding (MIG)

a. Starting the Unit - Turn on the ventilating system, water valve, gas system, and correct welder for wire size. Check electrode feed speed without making an arc. With diagonal pliers cut the electrode 1/2 to 3/4 inch in length. Touch metal with electrode before lowering helmet and pressing starter button on torch handle.

b. Do the welding in any position that it is done with the regular arc welder or tungsten gas welder. Vertical welding is usually accomplished in the same manner as regular arc welding, the movement being from bottom to top.

c. Metal is prepared for MIG welding in the same way as preparing for regular arc welding; that is, V-groove or weld square butt joints. As in TIG welding, the metal must be clean. Also, as in TIG welding, the MIG wire (electrode) size and current setting must be correct for the type of weld being made. However, the wire feed speed may be another factor to consider when doing this type of welding. When changing to a larger diameter wire (electrode), either the current must be increased or the speed of travel reduced. An example of speed is as follows. When welding approximately 26 inches per minute:

Mild steel - .060 thickness
DC amps - 130
Argon flow - 17 cu. ft. per hour

References:

1. Althouse, Andrew D., and Others, Modern Welding, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1976

2. Griffin, Ivan H., and Edward M. Roden, Welding Processes, Delmar Publishers, Albany, New York, 1970

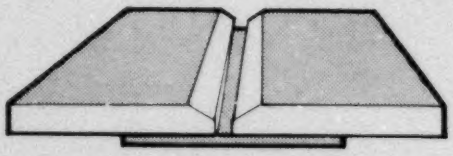
3. Morford, V. J., and Others, Metals and Welding in Agriculture, Hobar Publications, Division of Hobar Enterprises, Inc., St. Paul, Minnesota, 1970

4. "Shielded Metal - Arc Welding", Vocational Agriculture Services, University of Illinois, Urbana, Illinois, 1972

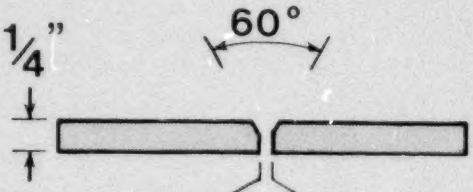
5. "Fundamentals of Service Welding", Deere and Company, Moline, Illinois, 1974

6. "Arc Weld It ... Yourself", Sears, Roebuck and Company, Chicago, Illinois, 1973

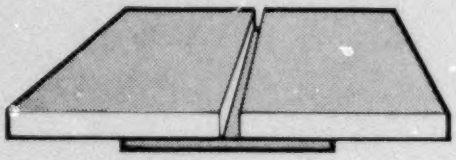
PROPER PREPARATION OF STOCK



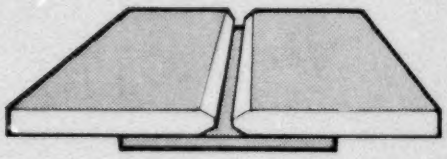
ONE SIDE BEVELED



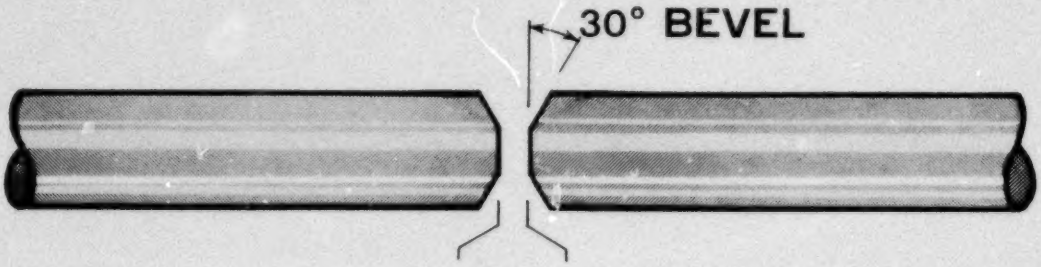
SPACED 3/32" APART



JOINT WITHOUT BEVEL



TWO SIDES BEVELED



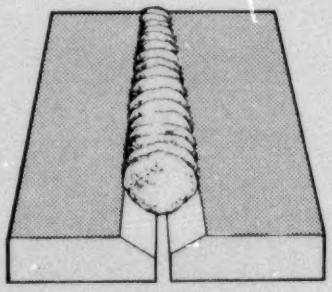
ROUND STOCK BEVELED ON TWO SIDES

ADJUSTING THE CURRENT

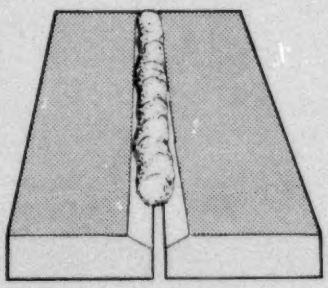
NORMAL BEAD

HIGH BEAD
(low penetration)

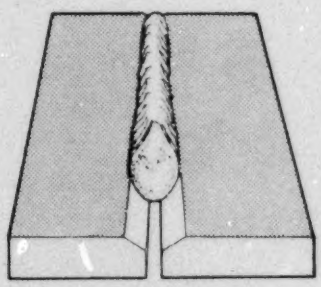
LOW BEAD
(under cutting)



CORRECT AMPERAGE



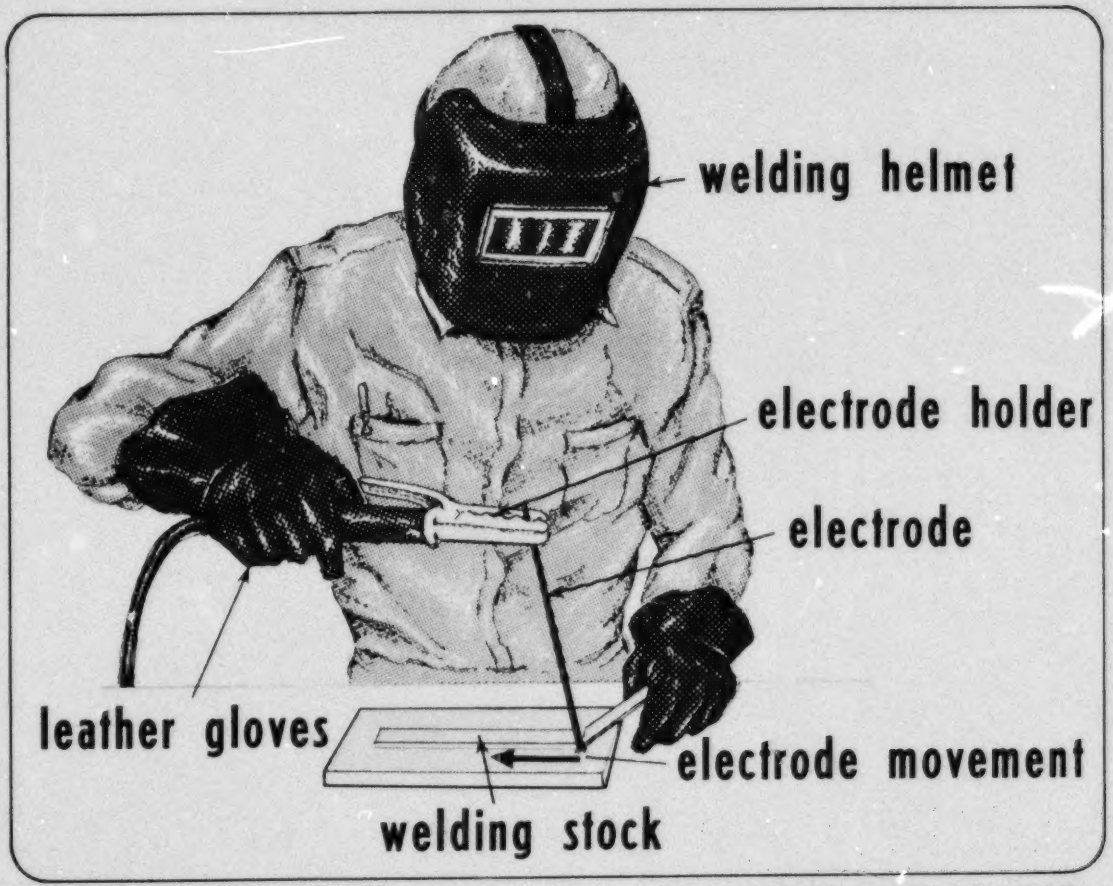
LOW AMPERAGE

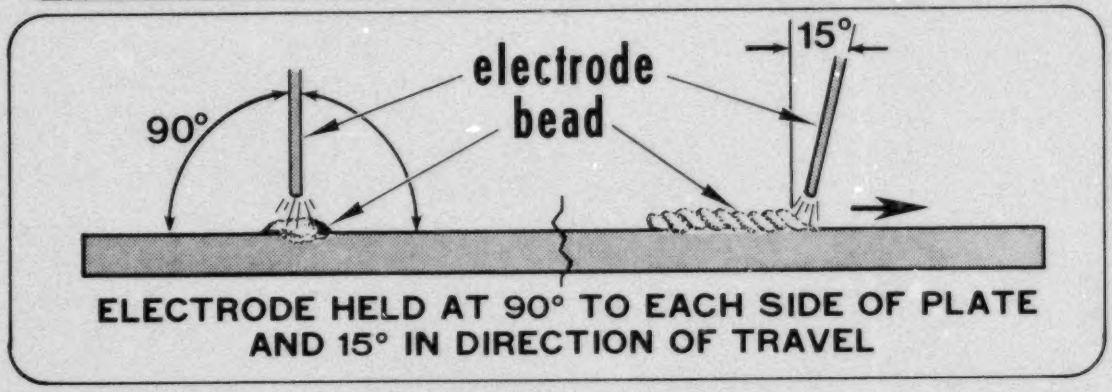


HIGH AMPERAGE

AMPERAGE	ELECTRODE SIZE	METAL THICKNESS
65	3/32"	1/16"
80-100	3/32"	3/32"
80-110	1/8"	1/8"
115-130	5/32"	3/16"
130-150	5/32"	1/4"
140-150	5/32"	5/16"
160-175	5/32"	3/8"
175-200	5/32"	1/2"

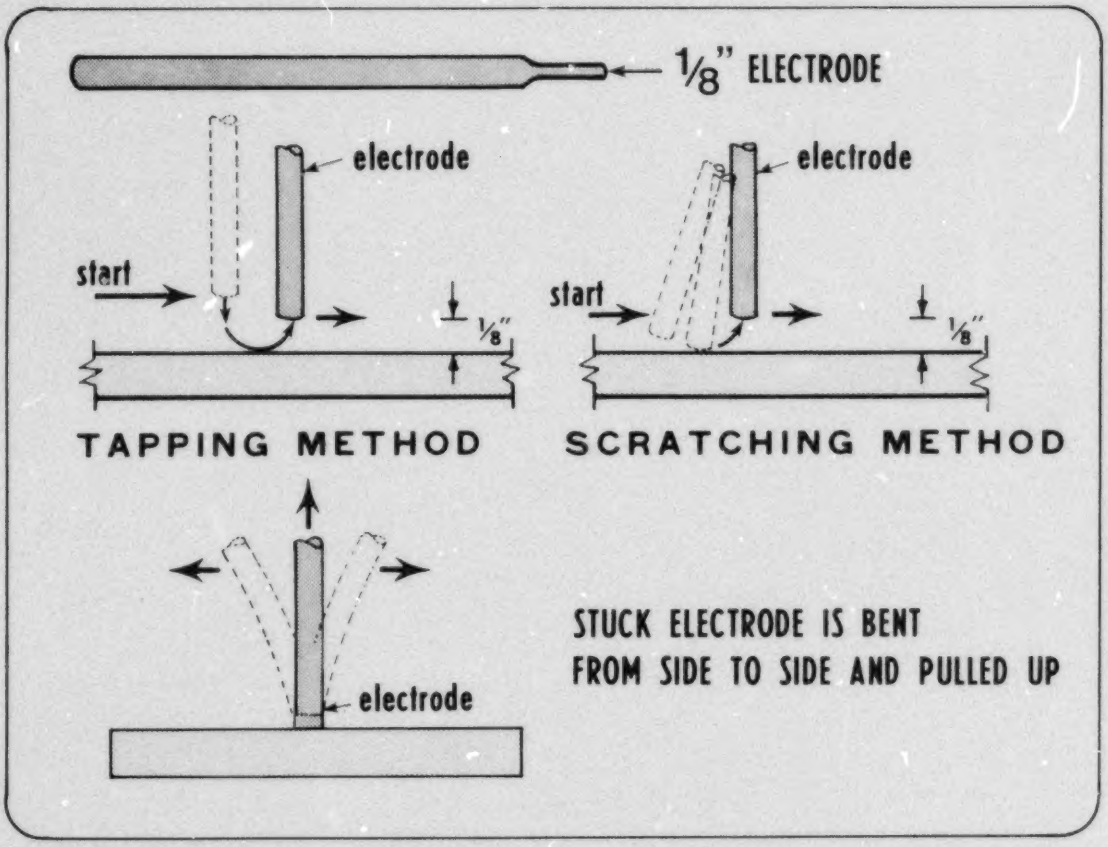
WELDING PROCEDURE



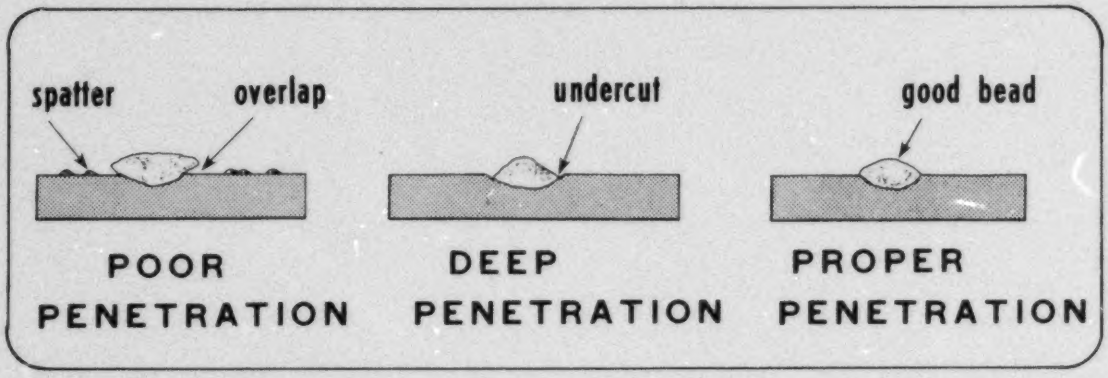


ELECTRODE HELD AT 90° TO EACH SIDE OF PLATE AND 15° IN DIRECTION OF TRAVEL

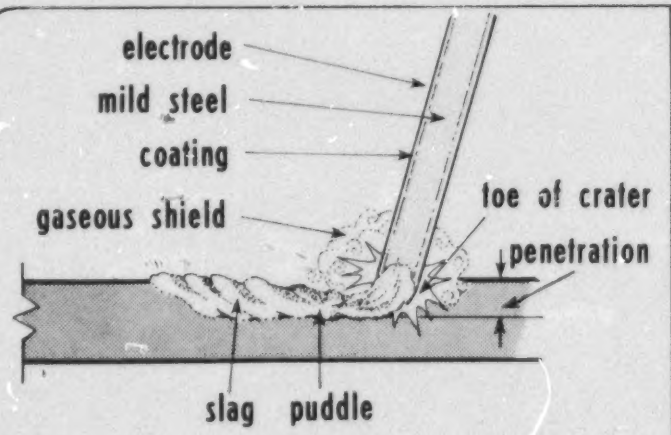
STARTING THE ARC



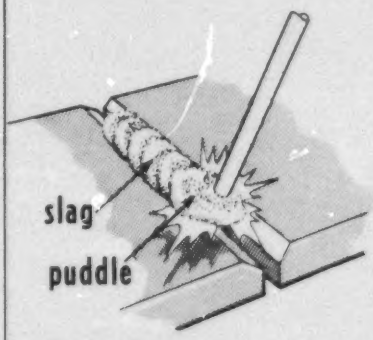
LAYING THE BEAD



STEPS IN RUNNING A BEAD



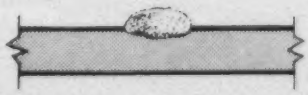
STARTING A BEAD AND MAINTAINING A GOOD PUDDLE



SLAG FOLLOWING BEHIND PUDDLE

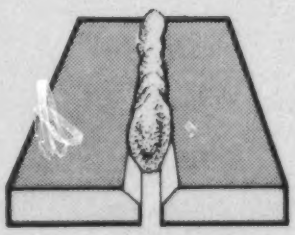
THREE TYPES OF BEADS

NARROW THIN BEAD

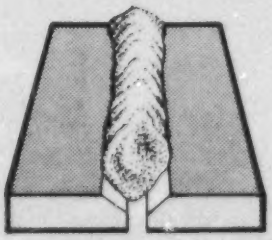


WIDE PILED-UP BEAD

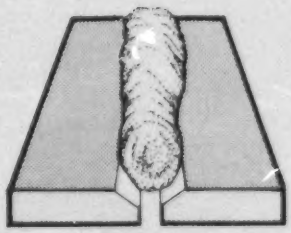
FLAT IRREGULAR BEAD



MOVING FAST

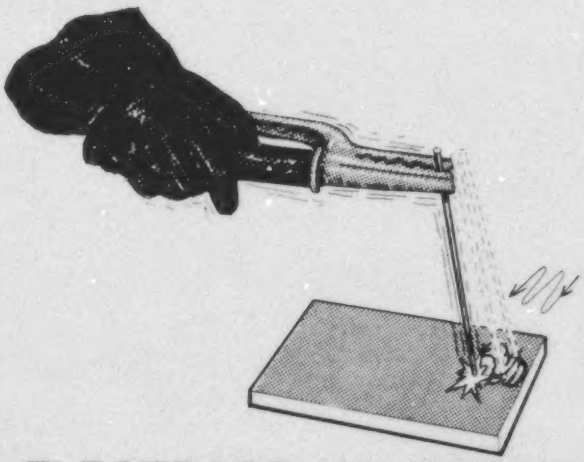


MOVING SLOW



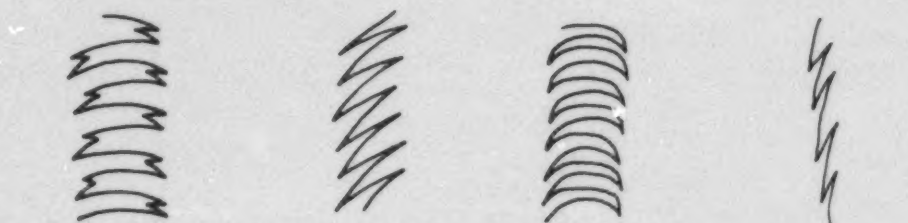
USING LONG ARC

STEPS IN RUNNING A BEAD



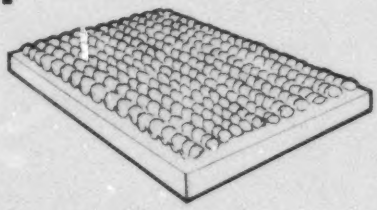
ELECTRODE MOVEMENT

TYPES OF WEAVING

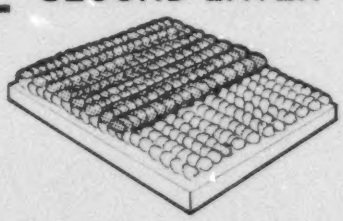


PADDING AND WEAVING

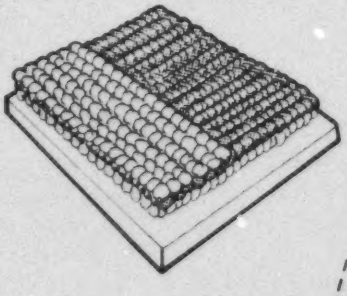
1 FIRST LAYER



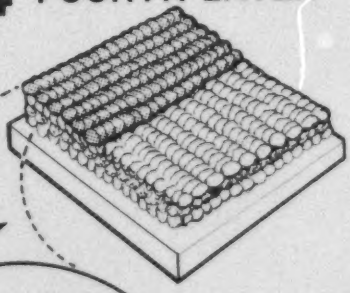
2 SECOND LAYER



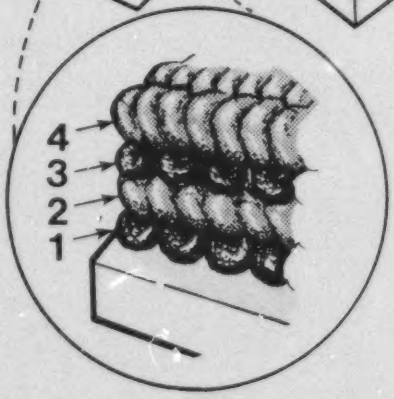
3 THIRD LAYER



4 FOURTH LAYER

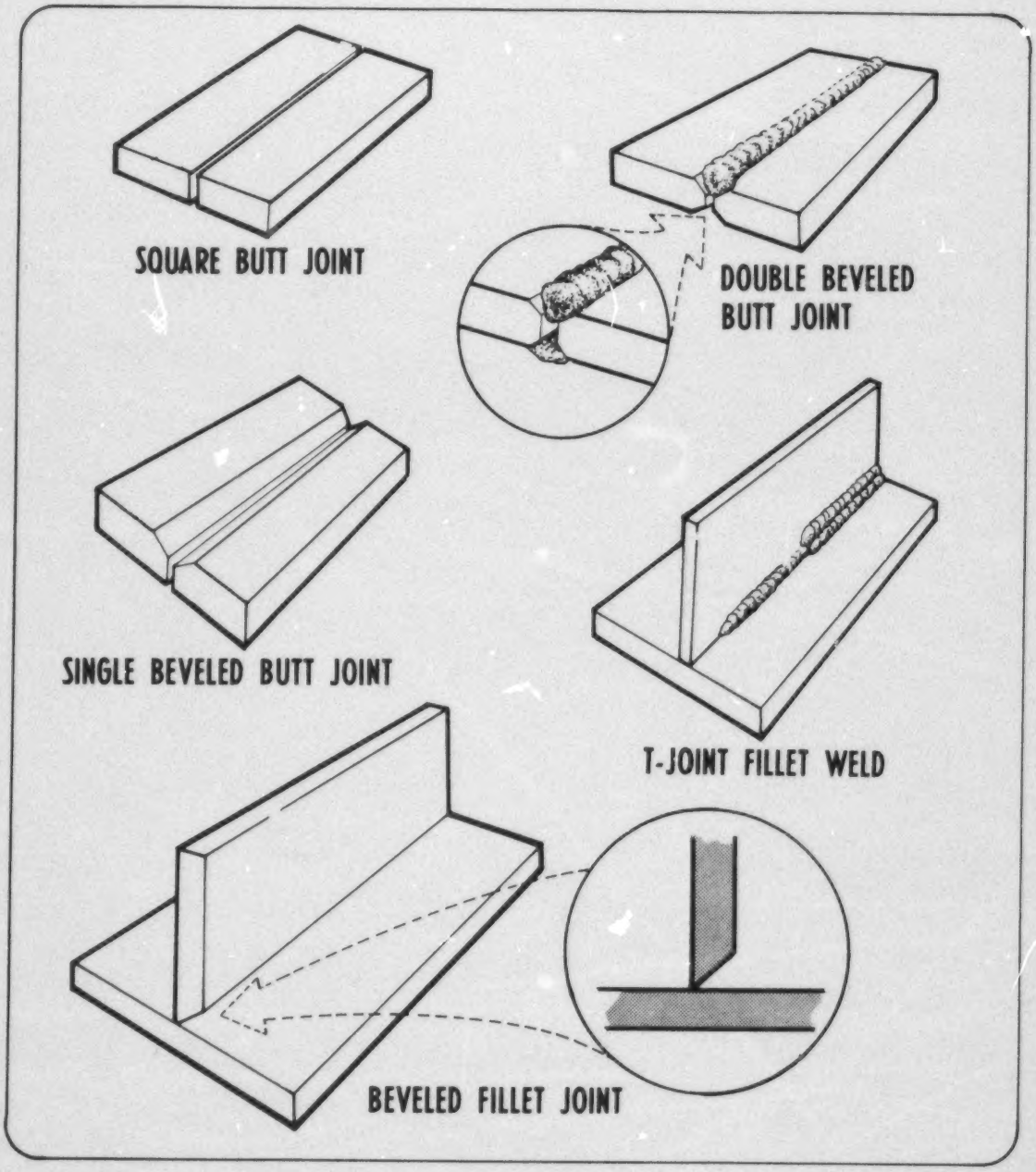


EACH LAYER
IS COVERED



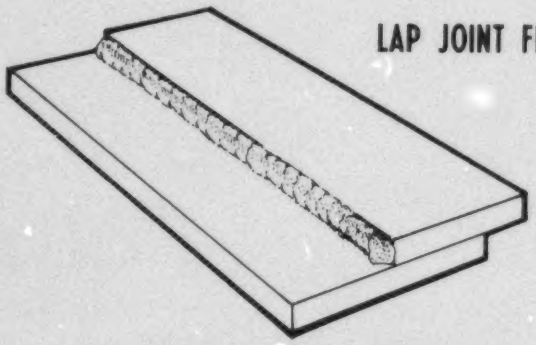
COMPLETE PAD HAS FOUR LAYERS

TYPES OF WELDS AND JOINTS



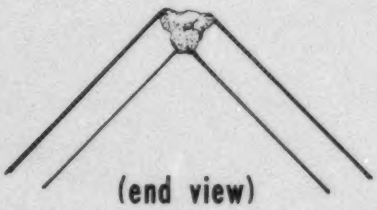
TYPES OF WELDS AND JOINTS

LAP JOINT FILLET WELD

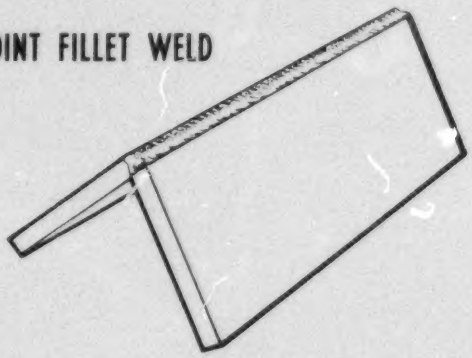


(end view)

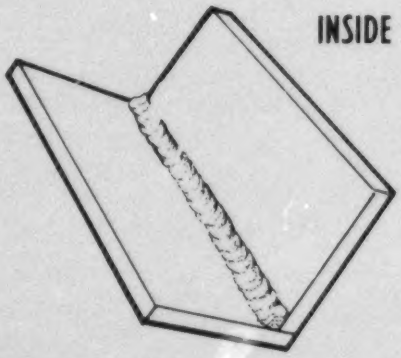
CORNER JOINT FILLET WELD



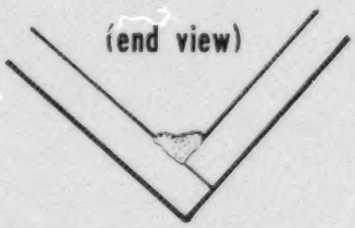
(end view)



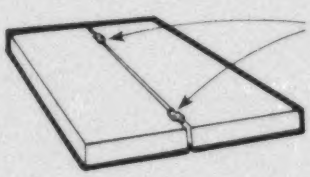
INSIDE FLAT FILLET WELD



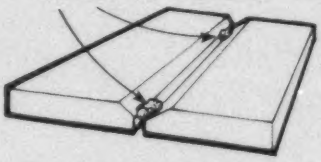
(end view)



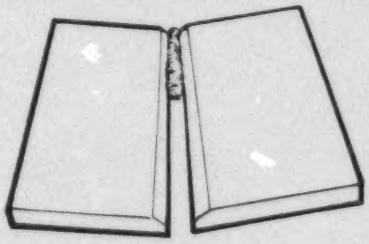
STEPS IN MAKING BUTT WELDS

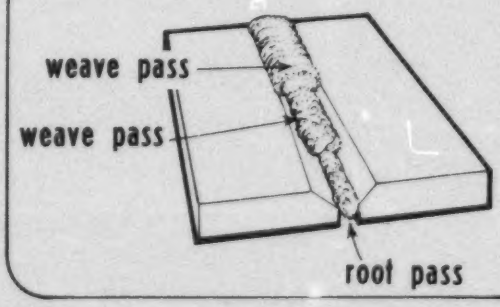


TACKS ON BEVELED METAL

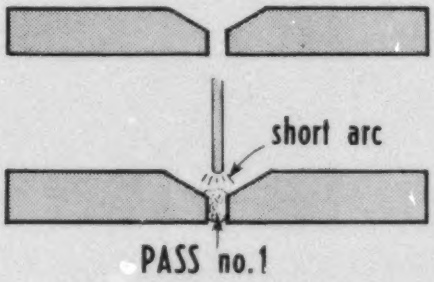


NO TACKS USED (metal moves apart)



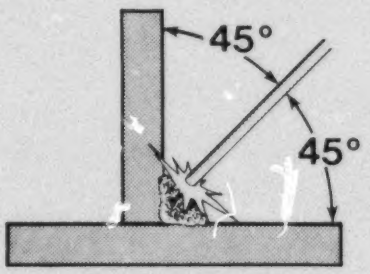


BUTT WELD PLATES

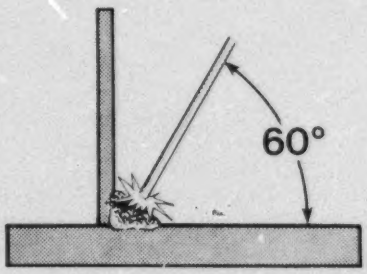


DOUBLE BEVELED
(pass on both sides)

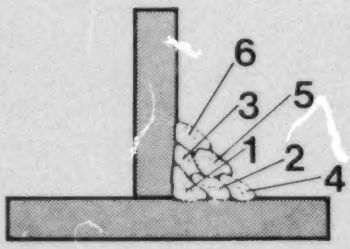
STEPS IN MAKING FILLET WELDS



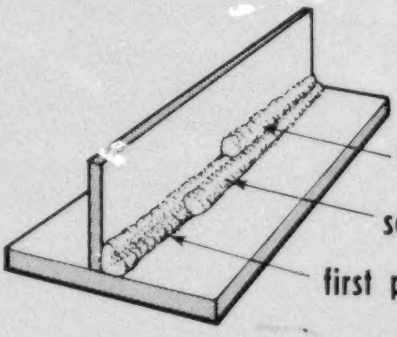
METAL WELDED FORMING "T"



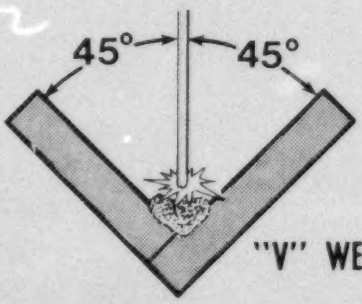
THIN METAL WELDED TO THICK METAL



SIX PASS WELD

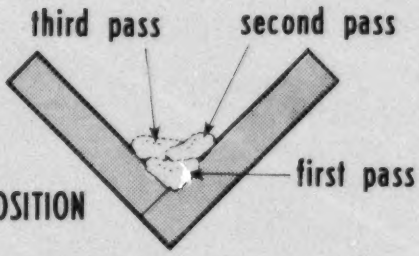


POSITION OF ELECTRODE

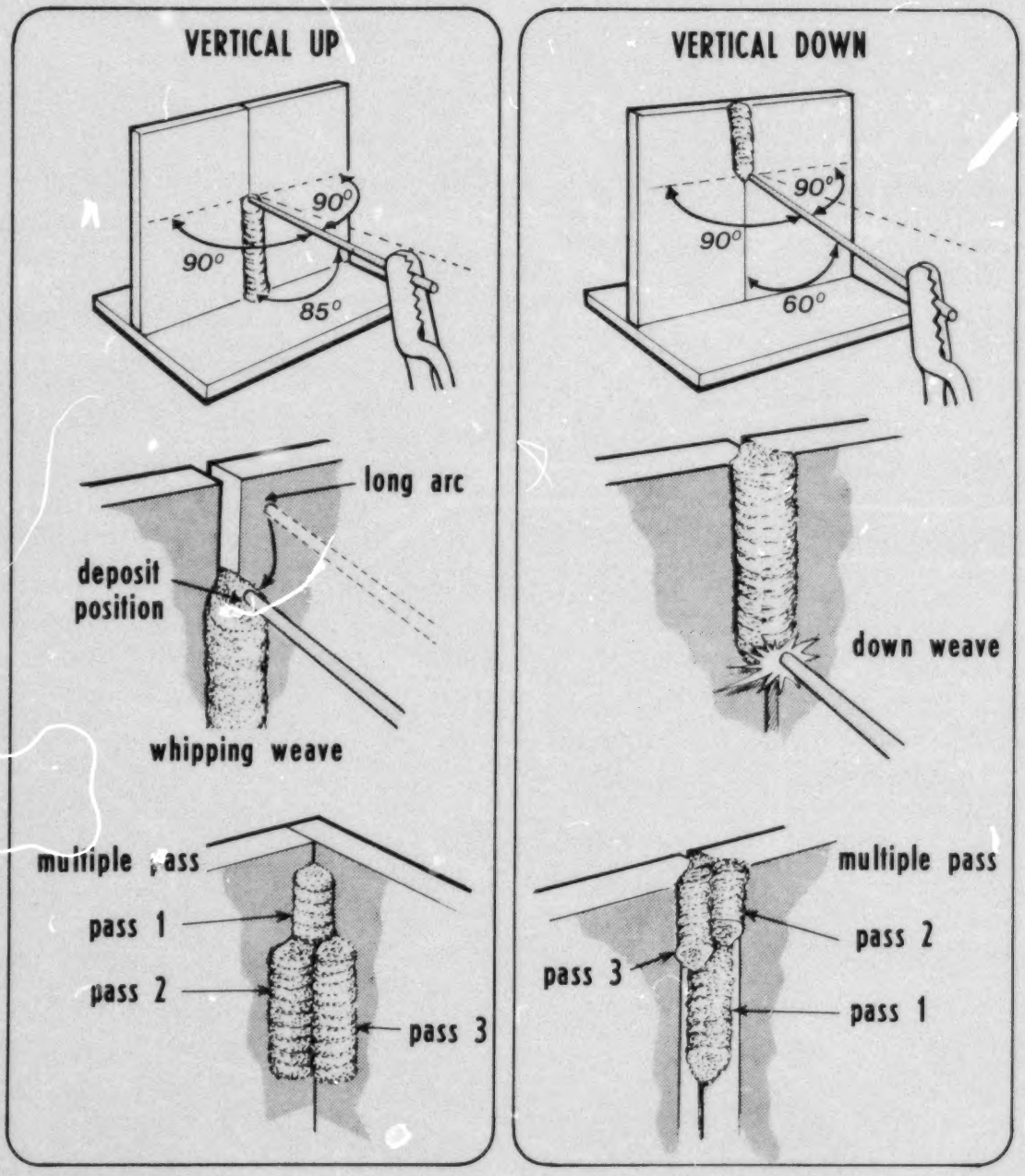


"V" WELD POSITION

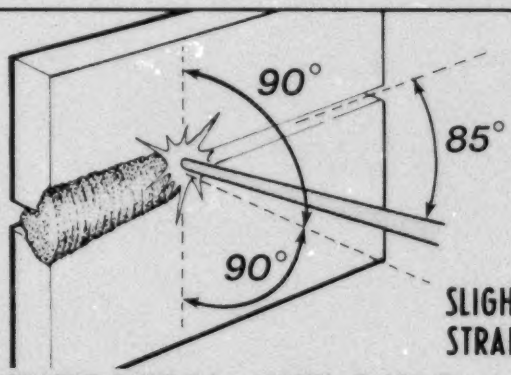
first pass 45°



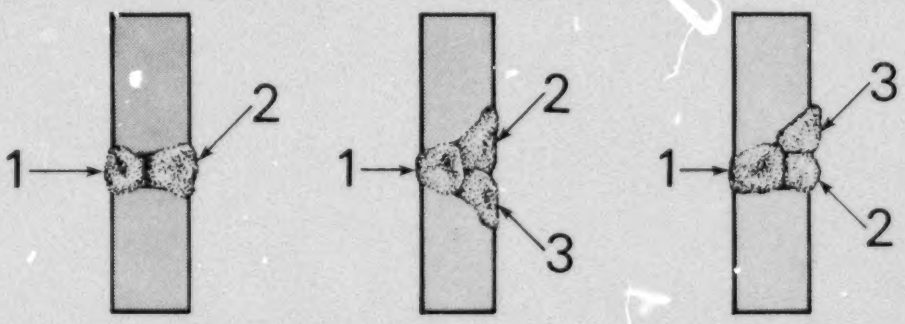
OTHER WELDING POSITIONS



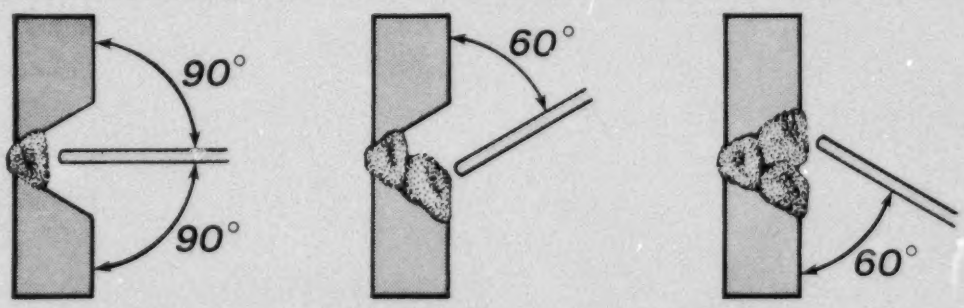
OTHER WELDING POSITIONS



HORIZONTAL WELDING

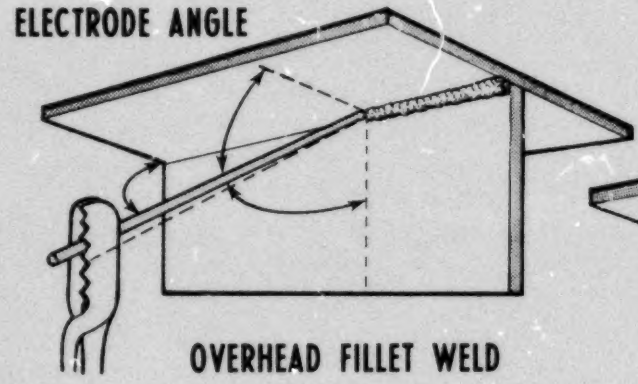


PASSES FOR WELDING HORIZONTAL BUTT JOINTS

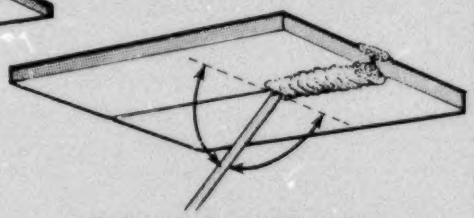


PROPER ELECTRODE POSITION - MULTIPLE WELDS

OTHER WELDING POSITIONS

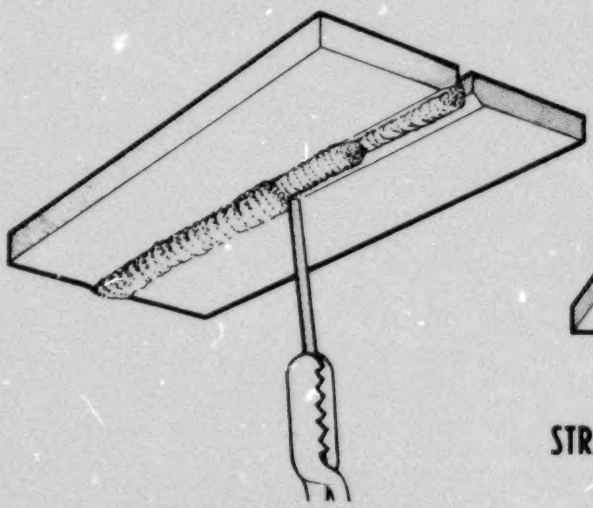


OVERHEAD FILLET WELD

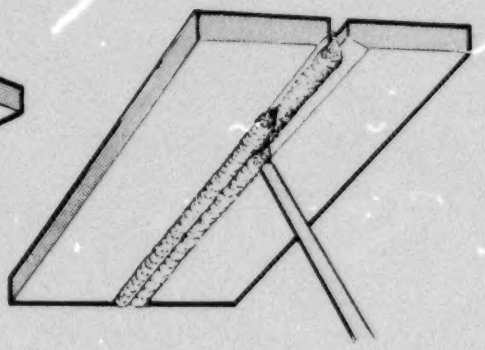


OVERHEAD BUTT WELD

OVERHEAD WELDING

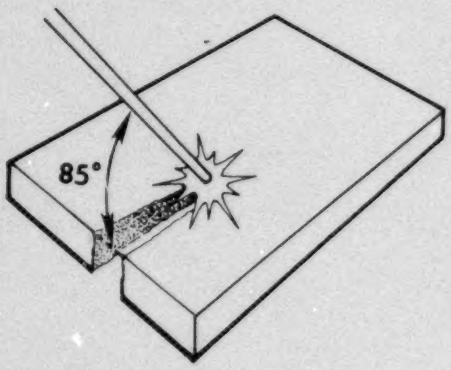


WEAVING BUTT WELD ON SECOND AND THIRD PASSES

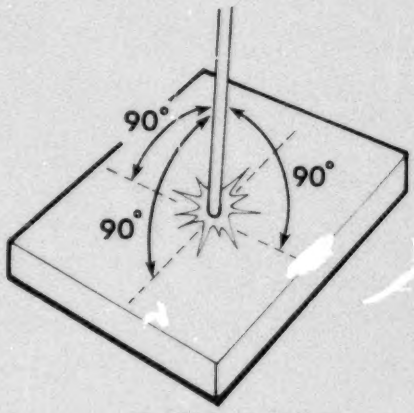


STRAIGHT BEADS FUSED TOGETHER

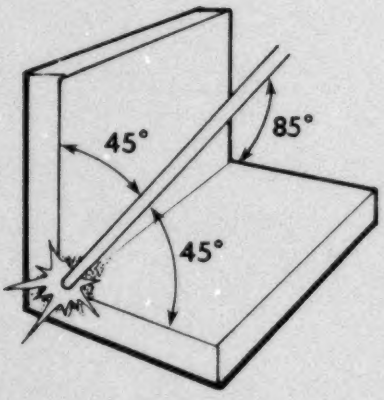
OTHER USES OF ARC WELDER



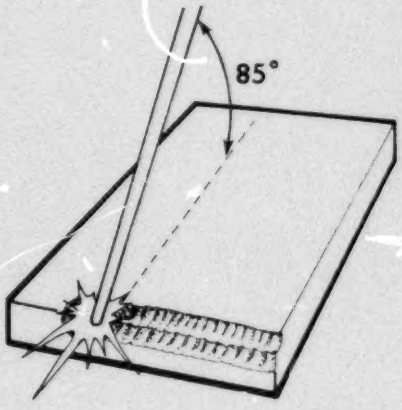
CUTTING



PIERCING

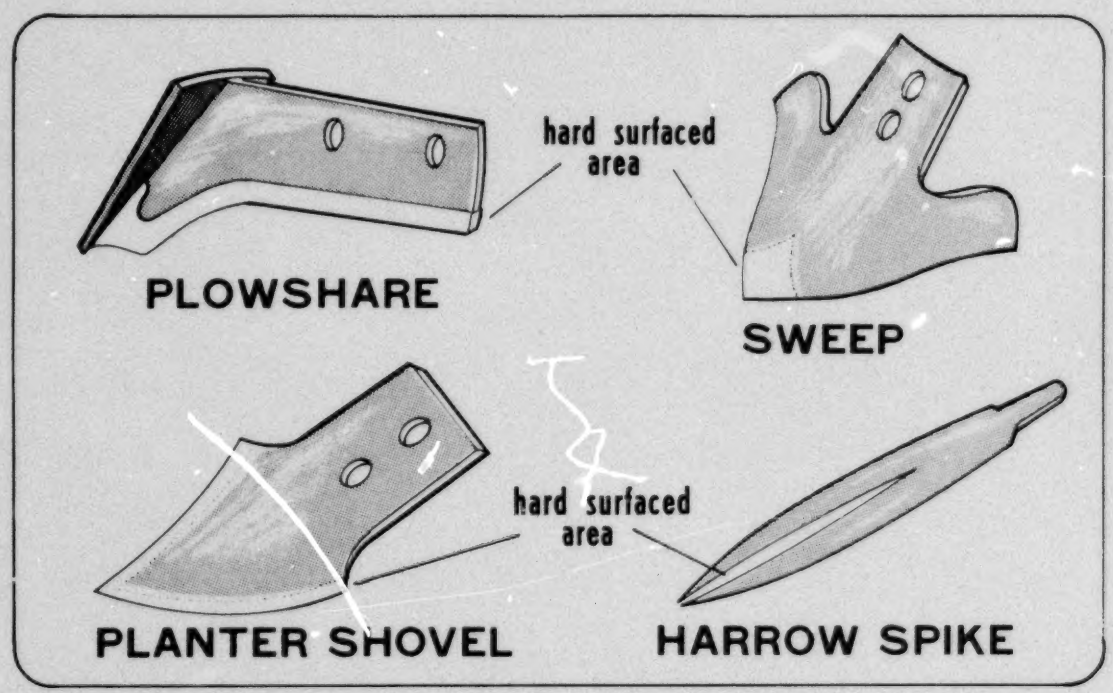


GOUGING

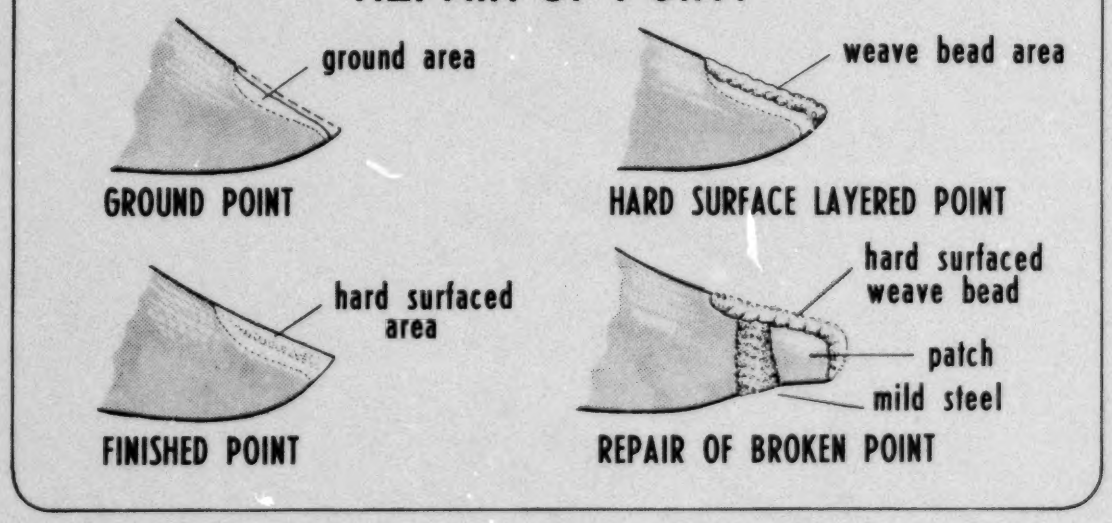


BEVELING

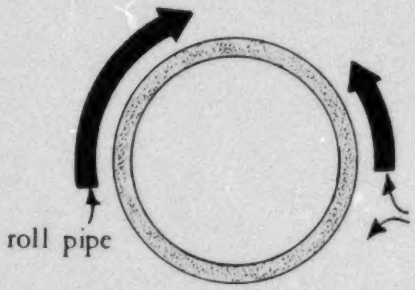
HARD SURFACING



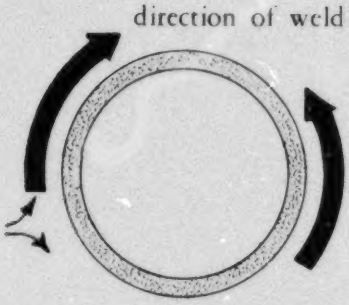
REPAIR OF POINT



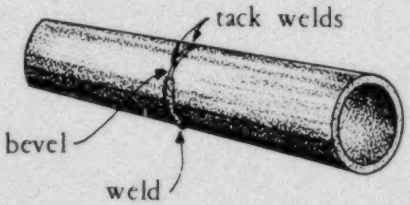
WELDING PIPE

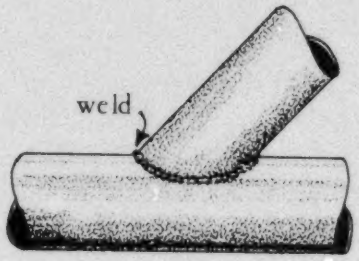


ROLL METHOD

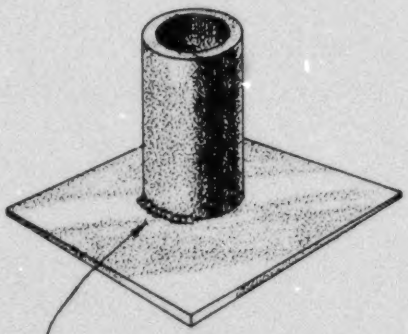


FIXED POSITION METHOD

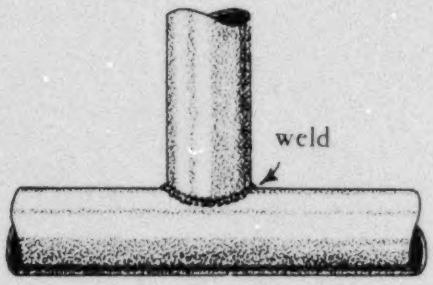




WELD ON 45° PIPE CUT



WELD TO PLATE



TEE WELD

HOT METAL WORK

Unit C: Soldering

Topic 1: Soldering Procedures, Equipment, and Materials

Note: Most of the information in this topic concerns the soldering of items of a general agricultural nature; however, some aspects of commercial soldering are included.

1. Introduction

Soldering is the process of joining two pieces of metal with the use of an alloy, which has a lower melting point than the pieces joined. Soldering should not be confused with fusion, the joining of two pieces of metal by melting. Solder penetrates the pores of metal and derives its strength from the penetration and the solder. Solder does not have the tensile strength (amount of pressure applied before a metal breaks) as that of a weld, and the tensile strength of solder will vary depending upon the solder used and the temperature at which it was applied.

Most solders are a mixture of tin and lead; however, traces of zinc, copper, aluminum, or other metals may be used in the mixture. The metals used and the proportion of each metal used in manufacturing solder affects the melting point of the solder. Pure tin melts or liquifies at 450 degrees F, while pure lead melts at 620 degrees F. Mixing the two in equal portions reduces the melting point to 400 degrees F. The more common solders are expressed as 40/60, 50/50, and 60/40. The first numbers always express the tin content.

A good all-around solder is the 40/60, while the plastic range of 50/50 solder is very narrow. The plastic range is the temperature range between when the solder begins to soften and when it becomes a liquid. The 60/40 solder has a narrow plastic range, a low melting point (361^{o}F.), and is used to solder metals such as pewter.

Since tin readily dissolves and will form an alloy with most other metals, it can be mixed in any proportion with lead. Tin is an imported metal and is more expensive than lead, which is abundant in this country. For this reason, solders having a higher proportion of tin are more expensive.

Transparency No. 1

The forms in which solder is usually available are solid wire, core wire, bar, and ribbon. Wire and bar solders are the most popular, while ribbon is the least used. Bar solder may be purchased in sizes ranging from one-half to 1½ pounds. It is cheaper in the bar form; and if large amounts of solder are to be used, the bar form is recommended. Rosin and acid are the most popular types of core solders.

Solders are classified as soft and hard. For general soldering, soft solder is the one used. Hard solder, referred to as silver solder by many, requires a high temperature (from 1300 to 1460°F) and has more tensile strength. It is used in areas where the base metal is exposed to a high temperature and more strength is required. Hard solder is made by mixing silver with small amounts of brass, zinc, or copper. Usually, an oxyacetylene or gas torch is used as the source of heat for hard soldering.

2. The Use of Fluxes with Solder

Fluxes are used with solder to clean the metal and prevent oxidization, the combining of metal with the oxygen in the air. The presence of oxide on the metal either causes the metal to reject the solder, or reduces the strength of the solder. Oxides may be present even though the metal appears clean.

Fluxes are classified as corrosive and noncorrosive and are available in paste, liquid, and powder forms. Corrosive fluxes must be removed by washing the area with water; otherwise, the flux residue will attract moisture in the atmosphere and cause a galvanic action. Corrosion due to galvanic action causes the metal near the solder to deteriorate.

Kinds and Uses of Fluxes
Corrosive Fluxes

Fluxes	Uses
Hydrochloric acid (Known as muriatic acid)	Old galvanized iron, old zinc, and for cleaning metal
Zinc chloride (killed acid) (Prepared by dropping zinc into HCL until the reaction stops)	New galvanized iron, new zinc, copper, and brass
Powdered sal ammoniac	Black iron, steel

Noncorrosive Fluxes

Rosin	Brass, copper, tin plate, pewter, (Especially for electrical wires)
Tallow	Lead

The method used to apply flux will depend upon the form used. Liquid forms of fluxes may be applied with a brush or plastic squirt bottle. Paste fluxes also may be applied with a brush. Powdered fluxes are sprinkled on the area to be soldered, or the point of the heated soldering copper may be placed in the flux and then placed on the metal to be soldered. One must be reminded, however, that the powder and paste forms of flux can be liquified if enough heat is applied to them.

3. Soldering Equipment

Transparency No. 2

Soldering Coppers

Soldering irons or coppers are used as the source of heat for most agricultural soldering. Both electric and non-electric coppers are used. The type and size to be used depends upon the amount of solder to be run, the metal to be soldered, the accessibility of electricity, location of the area to be soldered. and type of soldering to be performed.

Non-electric coppers range in sizes from one-half pound to several pounds. Three sizes of electric soldering irons are available: 100 watts, 200 watts, and 350 watts. Several different kinds of soldering guns are manufactured. They produce an intense heat at their tips and are used in inaccessible areas, areas having a flame hazard, or where intense heat is needed in a relatively small area.

The parts of the non-electric soldering copper are the handle, iron stem, bit or head, and tip. The bit is made from copper because it readily absorbs and transfers heat and is easily shaped and maintained. Wood is used for the handle because it absorbs very little heat and can be held without discomfort to the operator.

Sources of Heat

Transparency No. 3

The blow torch is used more than other source of heat in agricultural soldering and for heating non-electric coppers. However, a bench type gas furnace and other sources may be used. Radiator shops and other commercial establishments use soldering torches heated with a mixture of some form of gas and oxygen. Plumbers often use the self-contained gas torch. Soldering coppers generally are not used when torches provide the source of heat.

Other Equipment

Transparency No. 4

Other equipment used in soldering will depend upon several factors. The following is a partial list of equipment used in addition to the equipment listed above:

Safety glasses (Goggles having at least a No. 4 lens should be worn if an oxyacetylene torch is used.)
Gloves, acid resistant
Wire brushes (for cleaning metal and applying fluxes)
Glass, plastic, or crock containers with lids (Acid storage)
Tin snips
Files
Rivet sets
Electric drill and assorted bits
Table, asbestos top
Wood mallet (for shaping metal)
Center punch
Measuring and layout tools (Squares, calipers, marking gauge, etc.)

4. Tinning and Filing a Soldering Copper

A properly tinned soldering copper will hold solder on each of the sides that make up the top. The copper must be tinned to apply the solder correctly. Through continued use, the copper will lose its tin, become corroded and pitted, and fail to transfer enough heat to the base metal.

Transparency No. 5

The first step in tinning the copper is to heat the copper to a dark cherry red, place in a vise, and file the tip until all pit marks, dross (scum), and scale have been removed and the sides of the tip are bright and smooth. If the copper does not need reforging steps two and three may be omitted.

In step No. 2, the copper is reheated, placed in a vise, and the missharpen tip is driven back into the body of the copper.

The copper is reheated in step No. 3, held on an anvil, and forged to the correct shape with a ball pein hammer.

In step No. 4, the copper is reheated to the normal soldering temperature (dark cherry red), rubbed on a block of sal ammoniac while solder is applied to the underside of the copper. The copper is rubbed on the block and in the solder until the top will hold solder on all sides. Excess solder is removed by wiping the tip with a cotton cloth. Dipping the hot copper occasionally in a sal ammoniac solution will keep the tip bright and clean. The solution is made by dissolving one ounce of sal ammoniac in a quart of water.

Another method of tinning the copper is to heat the copper and rub it on a piece of tin on which solder has been placed.

5. Preparing the Surface for Soldering

The importance of preparing the surface to be soldered cannot be over emphasized. In order for the solder to penetrate the pores of the base metal, the metal must be clean. The procedure for cleaning base metal is as follows:

1. Metal is cleaned by grinding with a steel brush, or wire brush, or sanding with emery cloth or steel wool;
2. Muriatic acid is applied to the surface of the base metal to remove oxides;
3. Acid is removed by washing with water, and the metal is dried; and
4. Flux is applied if bar, ribbon, or solid wire solder is to be used.

6. Soldering Procedures

Using a Soldering Copper

Transparency No. 6

The maximum amount of heat is transferred to the base metal when the tip is in full contact with the metal. The solder--either solid wire, core wire, ribbon, or bar--is applied to one of the edges of the copper making contact with the base metal, rather than the point of the iron. As the solder liquifies,

the copper is moved along the seam or joint. The solder will flow rapidly if the copper is of the proper temperature and the copper is of adequate size.

The procedure for using a soldering copper is as follows:

1. Metal, seams, and/or joints are prepared;
2. Metal is cleaned thoroughly;
3. The soldering copper is heated (The use of two coppers will expedite the soldering; one copper is being heated while the other one is in use);
4. Flux is applied to the metal;
5. The heated copper is applied to the base metal;
6. Solder is applied to the copper;
7. Solder is run with the copper; and
8. After the solder has cooled, the flux is cleaned from the metal if a corrosive flux was used.

Soldering with a Torch

The two commonly used torches are the self-contained gas torch and the torch and tips. However, a limited amount of solder may be applied with a carbon arc torch.

The self-contained gas torch is particularly useful in "sweating" copper or other kinds of tubing. The strength of these joints is dependent upon the bond of the joint and not the amount of solder on the outer surface. The procedure for "sweating" a joint is as follows:

1. Tubing is cut to desire length;
2. Burrs and rough edges are removed from the tubing (both outside and inside);
3. The ends of the tubing and the inside of the joint are cleaned;
4. A thin coat of flux is applied to the inside of the fitting and to the area of the tubing that is to be placed inside the fitting;
5. The tubing is placed inside the fitting and is held against the shoulder of the fitting;
6. The fitting is uniformly heated on all sides;
7. Solder is applied until the joint is filled. (Because of capillary action, solder will flow throughout the joint if adequate heat has been applied);
8. Excess solder is removed from the joint with a cotton cloth, and the joint is allowed to cool; and
9. Joint is tested (for water tightness or other intended use).

Certain safety precautions should be followed when operating a torch and tips.

These are listed below:

1. Fire extinguishers (CO_2) should be in the working area;
2. All combustible materials should be free of gases before lighting torch;
3. Gas and oxygen lines should be free of gases before lighting torch;
4. The operator should be dressed in protective outer garments (goggles, gloves, apron, fire retarding outer garments, etc.);
5. The working area should be well-ventilated;
6. Gas is lighted before opening oxygen valve;
7. Oxygen and gas valves are closed when soldering is completed; and
8. Never point torch toward someone else or yourself.

The following gives the step-by-step procedure for setting up a soldering torch having tips:

1. Foreign matter is removed from the insides of hoses by blowing them out;
2. Air hose is connected to oxygen regulator, which had previously been connected to oxygen storage tank;
3. Gas hose is connected to gas regulator, which had previously been connected to gas storage tank;
4. Valves on torch are closed, and hoses (oxygen and gas) are connected to torch;
5. Gas regulator is opened;
6. Oxygen regulator is opened;
7. Gas storage tank valve is opened;
8. Oxygen storage tank valve is opened;
9. Gas regulator is adjusted to correct pressure (one pound is sufficient for most jobs);
10. Oxygen regulator is adjusted to correct pressure (one pound is usually adequate);
11. All fittings are tested for leaks by using a sponge that has been saturated with soapy water. The sponge is used to apply the soapy water to the joints. Air bubbles may be observed at a leaky joint.

Below is listed the procedure to follow when using the torch to solder (it is assumed that the metal has been prepared for soldering):

1. With the torch being pointed away from the operator and others, the gas valve is opened one-eighth of a turn; and torch is ignited with a friction lighter;
2. Flame is adjusted to about three inches in length;
3. Oxygen valve is opened slowly until the flame tapers and turns blue (See transparency No. 6 for flame sizes.);

4. If bar, solid wire, or ribbon solder is used, flux is applied to the area to be soldered;
5. The base metal is heated (The outer one-fourth of flame is applied to the base metal);
6. Solder is applied to the heated metal;
7. When soldering is completed, the gas valve on torch is closed (This valve is always closed first);
8. Air valve is closed on torch;
9. Valve on gas storage tank is closed;
10. Valve on oxygen storage tank is closed;
11. Gas and oxygen valves on torch are opened;
12. Pressure is released on gas and air regulators;
13. Valves on torch are closed; and
14. Flux is cleaned from metal if a corrosive flux was used.

The carbon arc torch is attached to the ground and electrode holder of an arc welder. It is capable of producing a flame with a heat intensity of 9,000 degrees F. The size of carbon rods used on the torch depends upon the amount of heat required, thickness of metal, and kind of metal.

Size of Carbon	Welder Amperage	Metal Thickness
1/4 inch	20-50	up to 1/40 inch thick
5/16 inch	30-70	1/40 to 1/20 inch thick

The carbons used for a torch connected to an A.C. welder should be the same size, while the carbon on the cable connected to the electrode holder on a D.C. welder should be one size larger.

The carbon tips are extended about two inches below the carbon holders on the carbon arc torch and should form a vee. The arc is started by moving the carbons toward each other. After the flame has started, the carbons are adjusted to about 3/16 of an inch apart. The same soldering procedure is followed with the carbon arc torch as is used with other torches.

7. Some Joints Used in Joining Soldered Metals

Several different kinds are used in joining metal to be soldered. The joint used will depend upon the item to be soldered, kind of metal, strength required, location in which item will be used, and preference of worker.

Transparency No. 7

If possible, interlocking joints or other similar types of joints should be used when joining sheet metal, but this is not always possible or practical. However, in most cases joints can be reinforced with solder. One method of reinforcing butt joints is to solder on both sides of the joint. Another method is to place two pieces of masking tape parallel to the edges to be joined and about half the width of the bead from each edge. The tape prevents the molten solder from spreading and allows more solder to be placed on the joint. Flux and solder are applied between the strips of tape on both sides of the metal.

Soldering on each side of a lap joint also will reinforce the joint. The use of a strip of metal on the underside of a butt joint is still another means of reinforcing a joint. The use of a sleeve made from tubing and a metal collar are used to reinforce tubing and bars.

Transparency No. 8

In the above transparency are illustrations of riveting, "sweating" two pieces of metal, and soldering around rivets to make the joint water tight.

To "sweat" two pieces of metal, each piece is tinned where the two pieces are to be joined, the pieces are placed together, and heat is applied until the tinned covering on the metal melts.

The procedure for soldering riveted seams is as follows. (This is after the metal has been cleaned.);

1. Drops of solder are placed at intervals along the edge of the seam;
2. A flat side of the heated soldering copper is placed on the seam until the solder melts and flows into the seam and around the rivet; and
3. The soldering copper is moved slowly along the seam until all drops of solder are melted and have flowed into the joint and around the rivets.

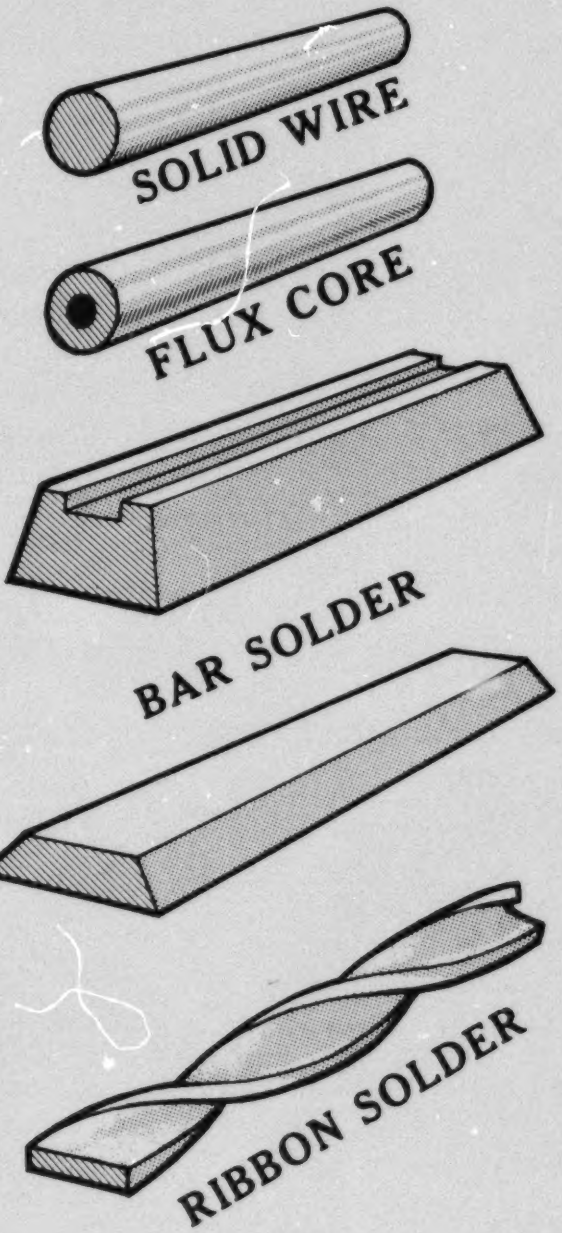
References:

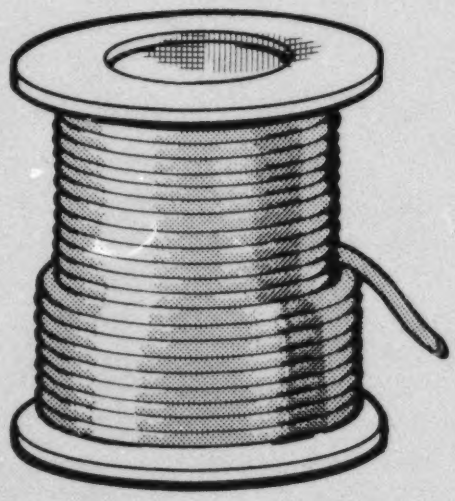
1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

2. Walker, John R., Modern Metalworking, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1968

3. Horowitz, Harry, Auto Radiator Repair and The Cooling System, Mc Graw-Hill Book Company, New York, New York, 1972

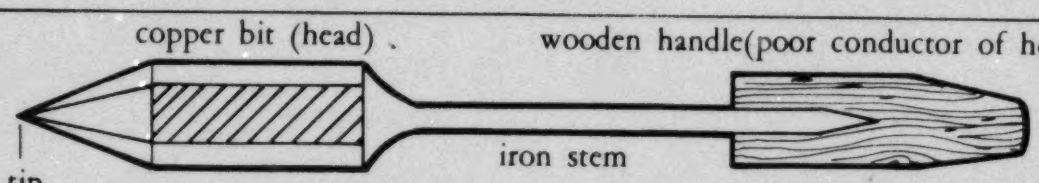
SOLDER FORMS





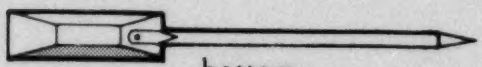
WIRE SOLDER

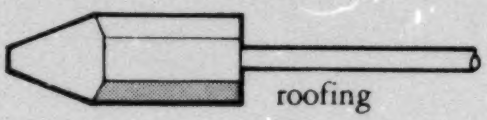
SOLDERING COPPERS (IRONS)

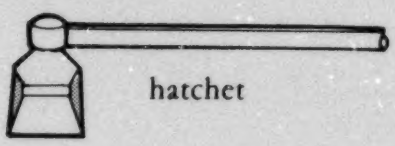


PARTS OF A NON-ELECTRIC SOLDERING COPPER

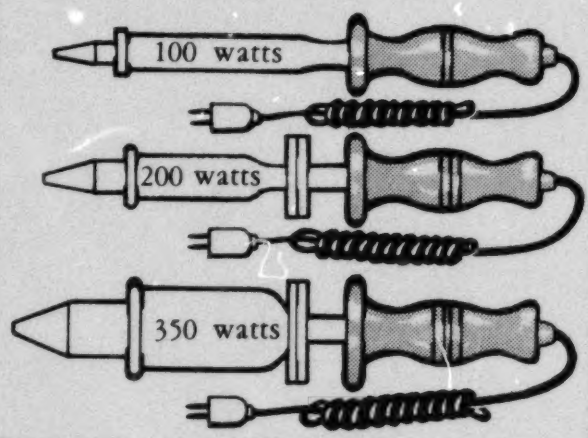
NON-ELECTRIC COPPERS



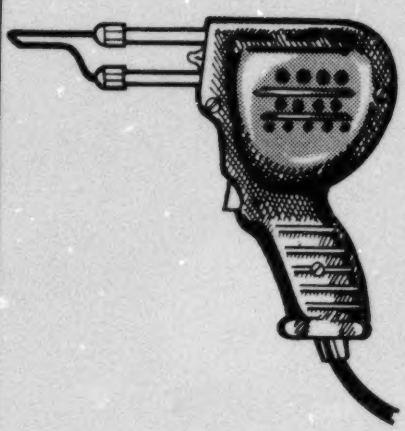




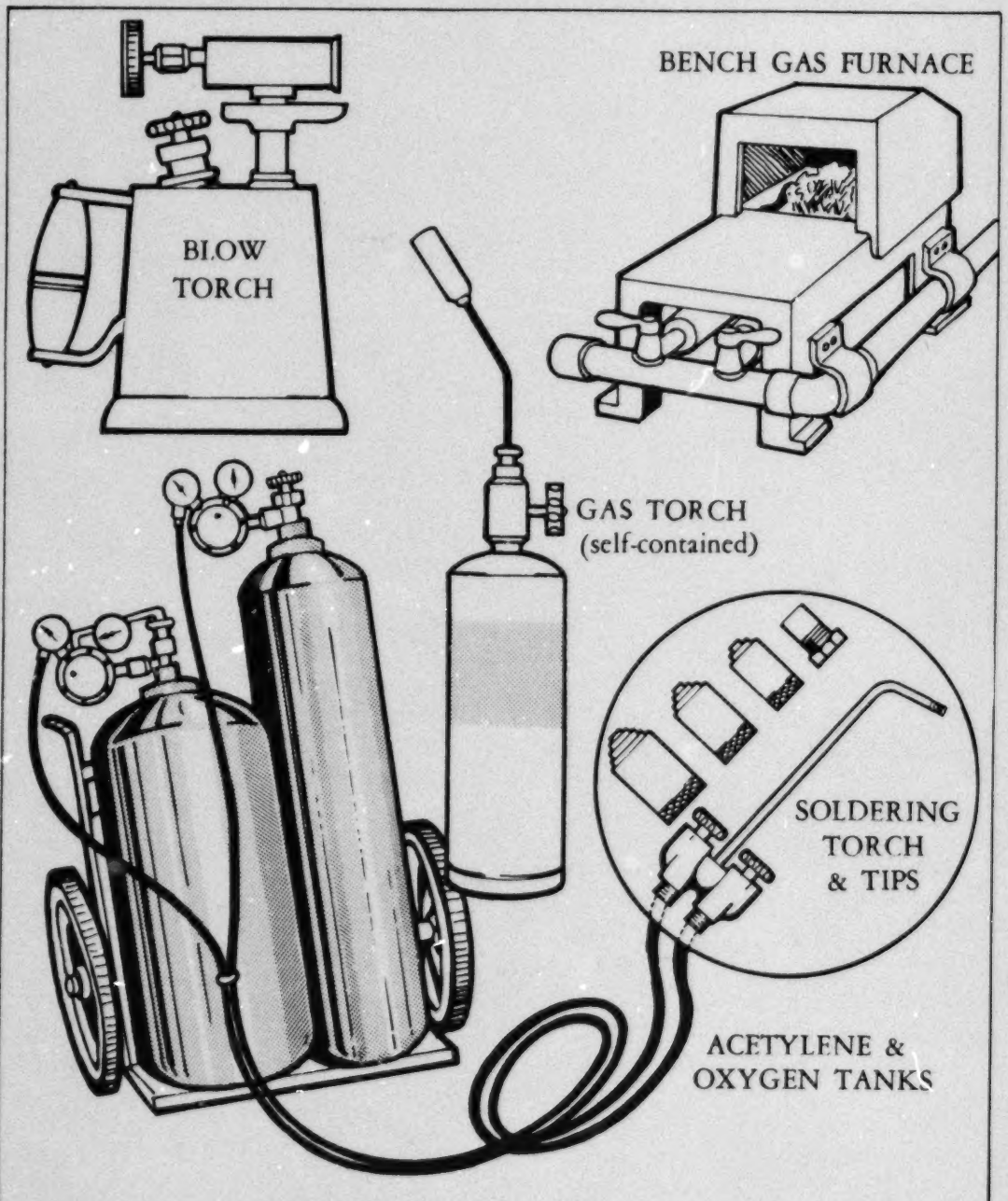
ELECTRIC SOLDERING COPPERS



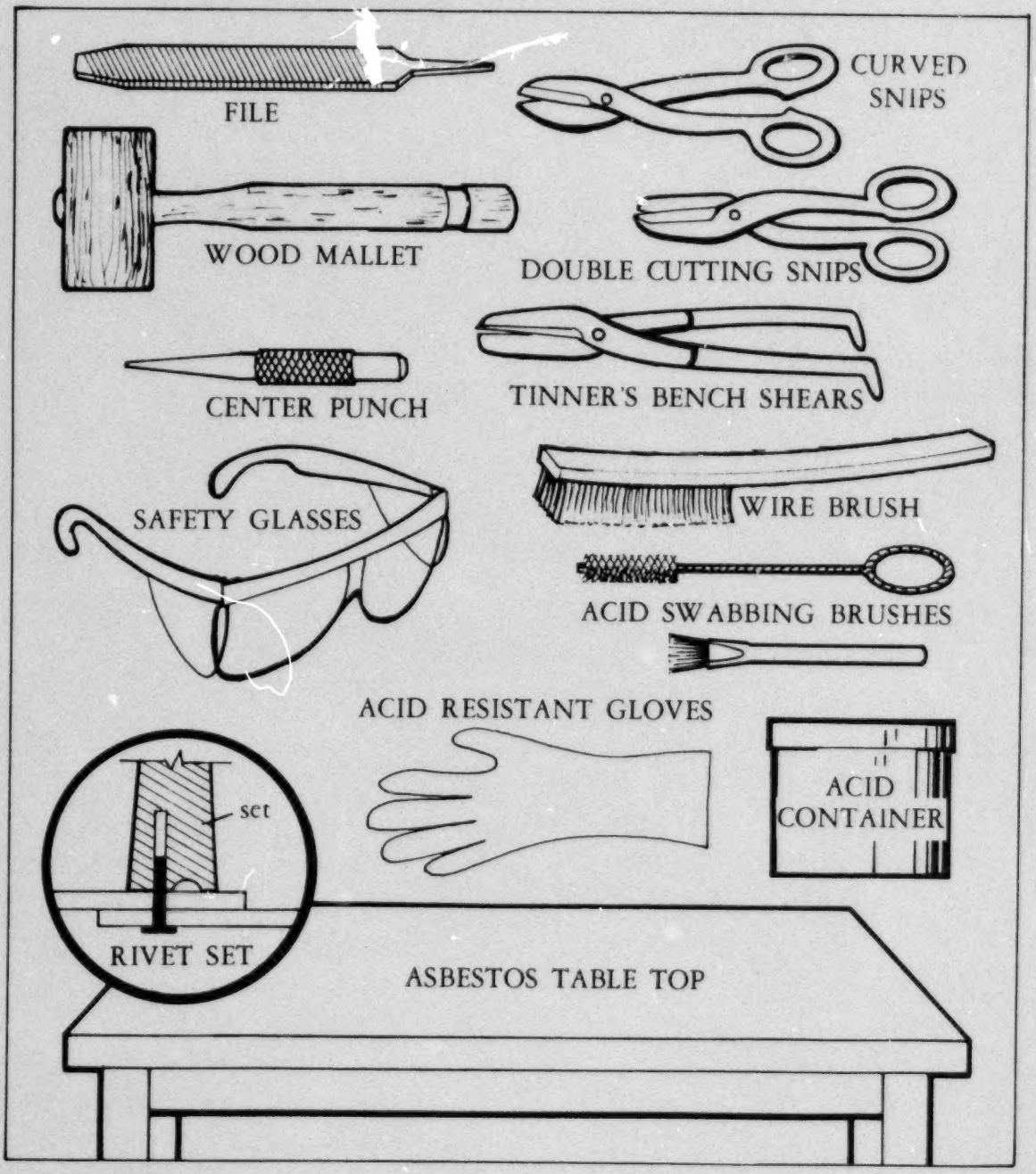
SOLDERING GUN



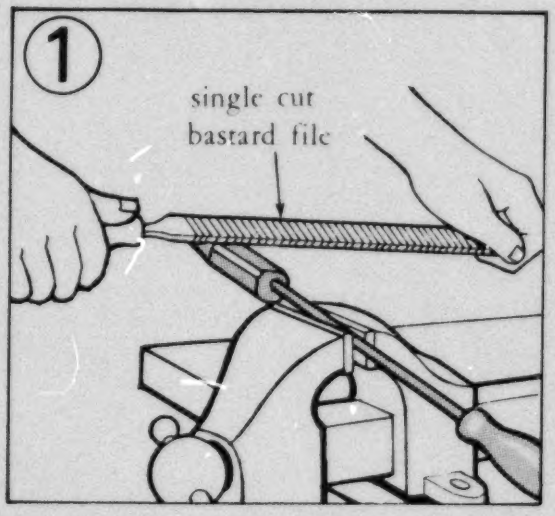
SOLDERING IRON HEATING EQUIPMENT

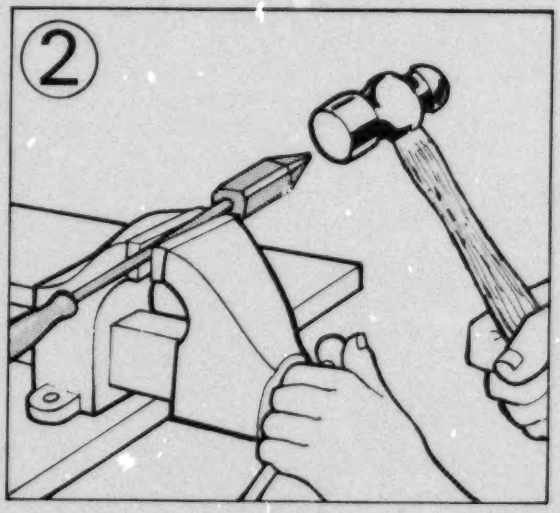


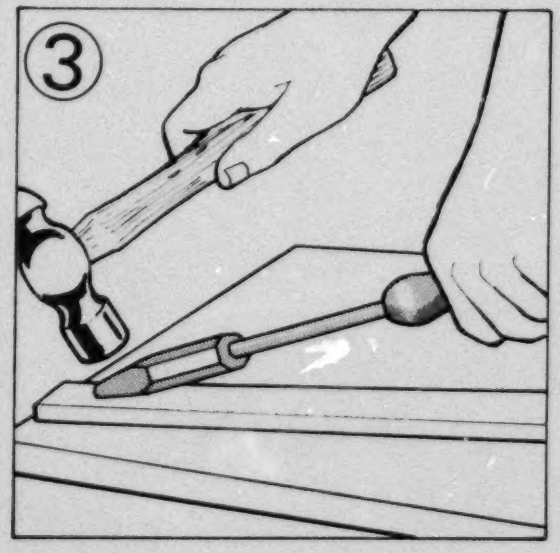
SOLDERING EQUIPMENT

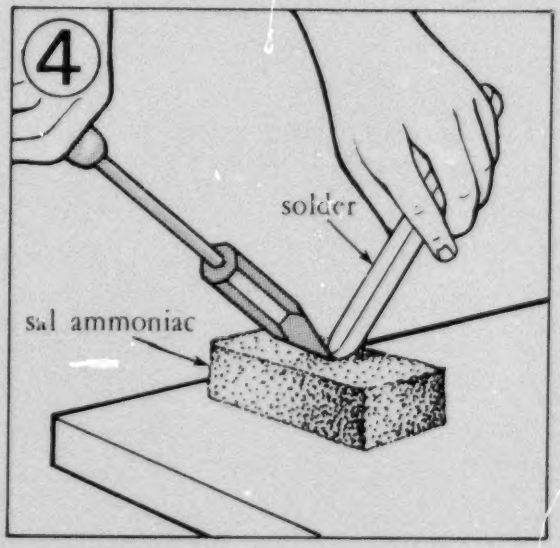


TINNING A SOLDERING COPPER

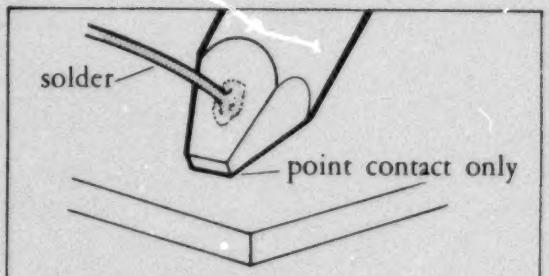




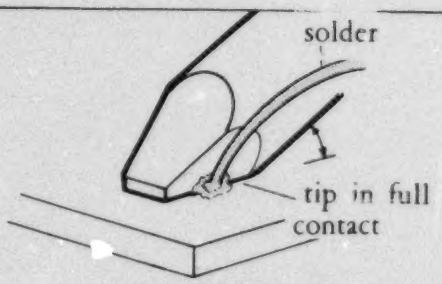




HOLDING IRON & APPLYING SOLDER



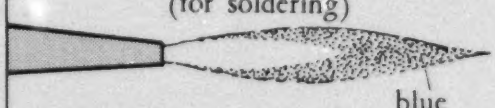
INCORRECT

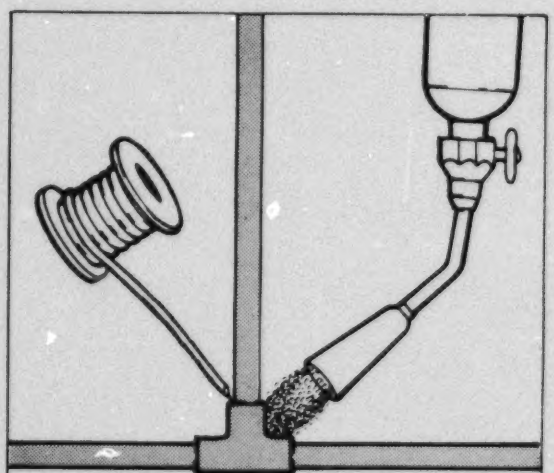


CORRECT

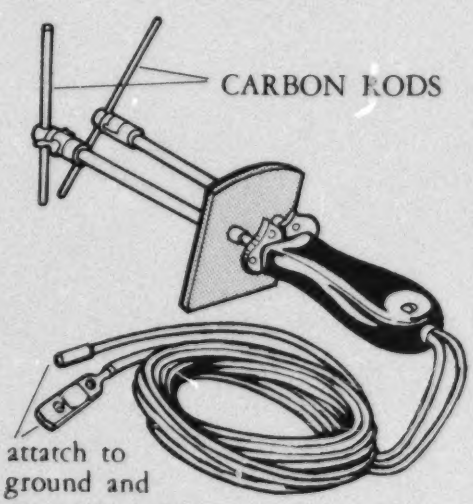
GAS FLAME WITHOUT OXYGEN

GAS FLAME WITH OXYGEN
(for soldering)



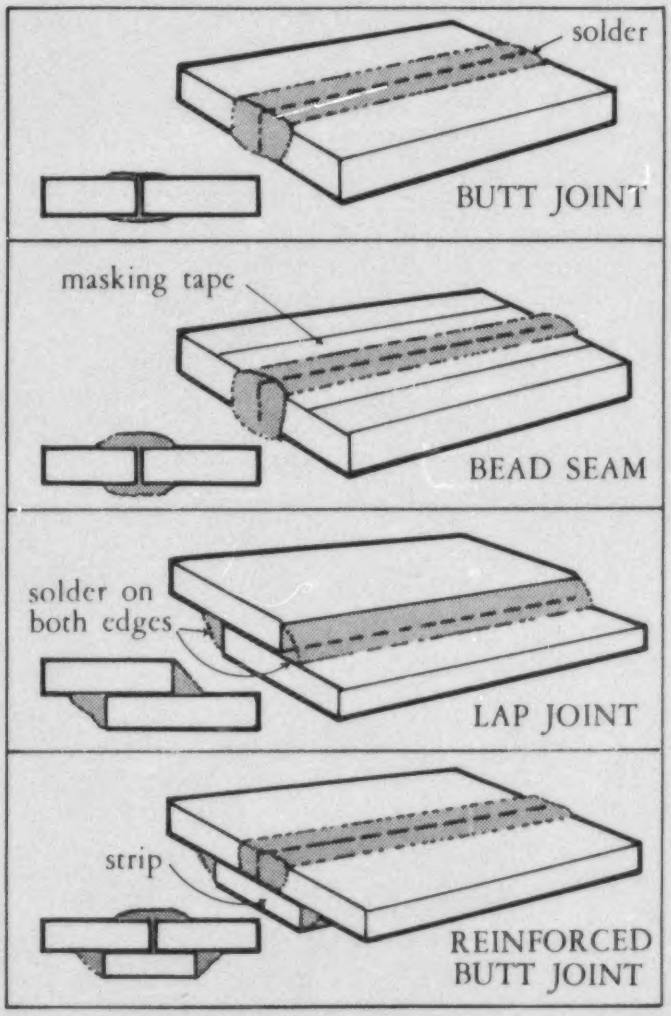


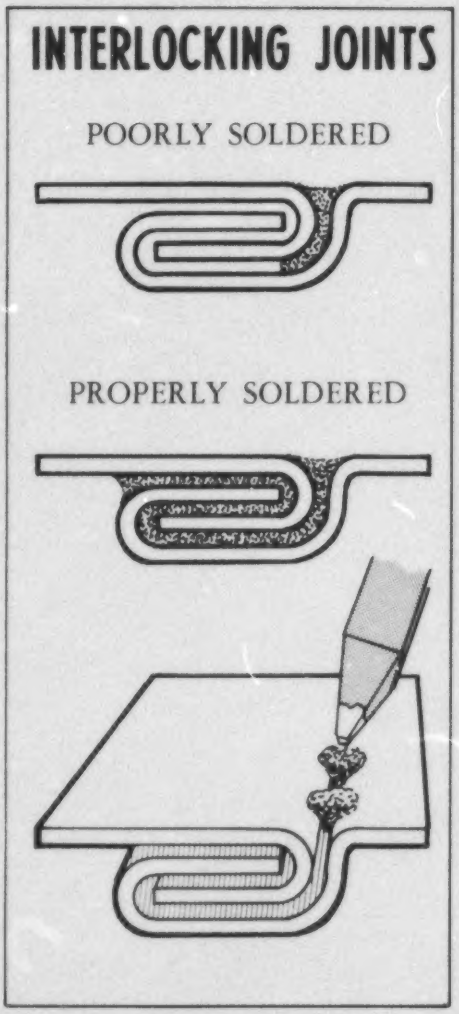
GAS TORCH
(for bonding joints)

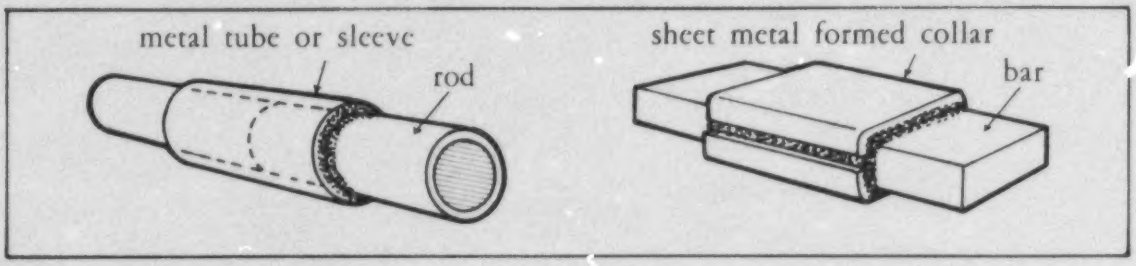


CARBON ARC TORCH

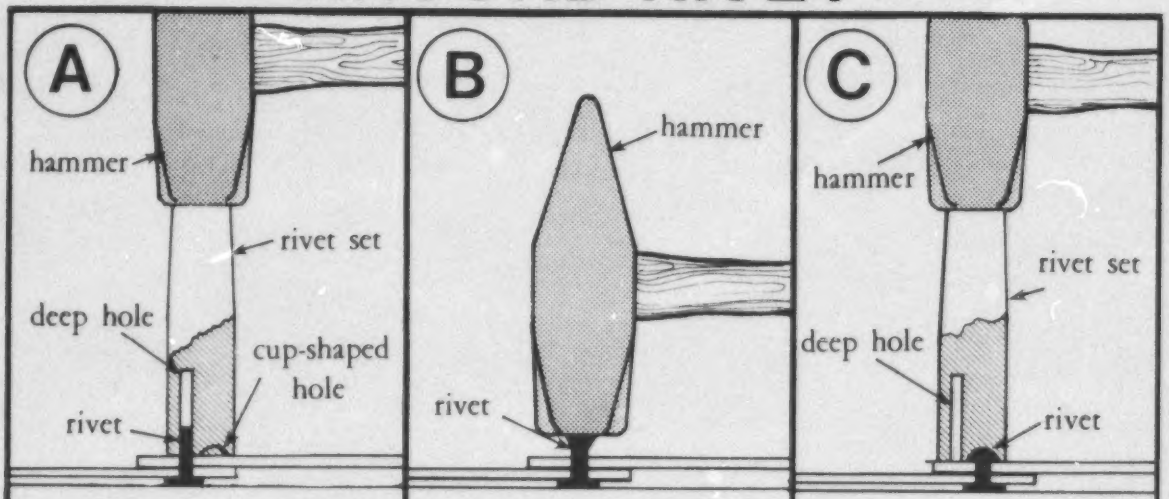
JOINING SOLDERED METAL







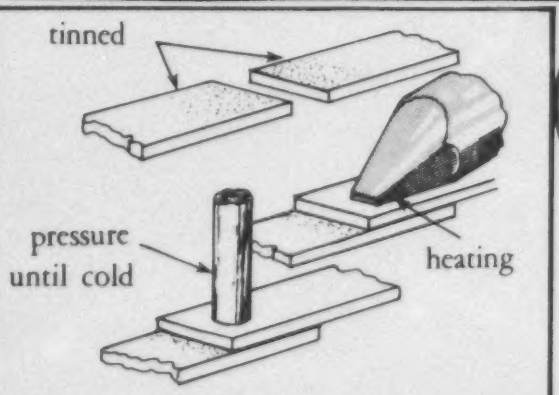
RIVETING THIN SHEETS OF METAL AND SOLDERING AROUND RIVET



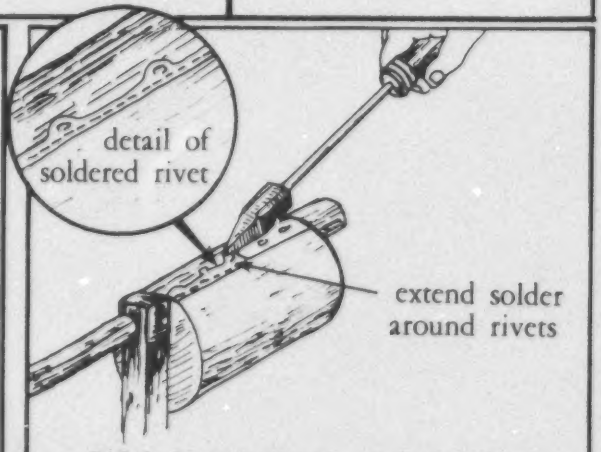
DRAW SHEET METAL TOGETHER

TIGHTEN RIVET WITH HAMMER

FORM HEAD



"SWEATING" TWO PIECES OF METAL TOGETHER



SOLDERING AROUND RIVETS

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A: Small Gasoline Engines

Topic 1: Basic Principles of Two and Four Cycle Engines

Suggested Procedures and Activities: The use of partially disassembled engines as teaching aids during the class discussion may be helpful in presenting the lesson.

Transparency No. 1

1. The Use of Two and Four Cycle Gasoline Engines

The small internal combustion engine is a very important source of power both on and off the farm. It is estimated that more than 6,000,000 small engines are produced annually in the United States. The total number of single-cylinder engines in the United States may exceed 70,000,000.

a. Small engines are adaptable to many kinds of jobs because they are:

Lightweight	Air-cooled
Portable	Furnish power
Compact	Easy to service and repair
Economical on fuel use	

b. Some equipment that may be powered by small engines is as follows:

Mowers	Brush cutters
Chain saws	Rotary tillers
Conveyors	Irrigation pumps
Elevators	Sprayers
Post hole diggers	Concrete vibrators
Air compressors	Concrete surfacers
Outboard motors	Small tractors
Small seed grinders	Generators

c. Small engines used to power this type of equipment are known as internal combustion reciprocating engines. A combustible mixture of petroleum products and air in the piston chamber (cylinder) is burned to form heat which is the source of power. The shaft is turned as pressure is applied to the top of the piston, forcing it down as the air-fuel mixture burns and expands in the cylinder. The piston is connected to a connecting rod which is connected to the crankshaft.

2. Major Differences in Two and Four Cycle Engines

Two Cycle	Four Cycle
Piston or thin piece of metal over an opening (reed valve) serves as a valve.	Has regular intake and exhaust valves.
Oil is mixed with gasoline and used as a fuel and lubricant.	Oil is used entirely as a lubricant.
One revolution of the crankshaft is a cycle.	Two revolutions of the crankshaft are one cycle.
Crankcase contains a fuel that also serves as a lubricant.	Crankcase contains only a lubricant.
Two strokes of the piston complete one cycle.	Four strokes of the piston complete one cycle.
Has no camshaft, valve lifters, or valve springs.	Has valve lifters, valve springs, and a camshaft.
Less difficult to handle on small hand equipment.	More difficult to handle on very small equipment.
More difficult to start than four-cycle.	May start more easily than two-cycle. Burned and unburned gases are not likely to mix.
More power produced per unit of weight. This is important in using light equipment.	Less power produced per unit of weight because there is a power stroke every two revolutions of the crankshaft.
May be used in any position due to having no crankcase and float type carburetor.	Used in certain position due to having oil in crankcase and float type carburetor.
Lubricating oil is mixed with engine fuel, resulting in a less efficient job of engine lubrication.	Easy to lubricate. Fuel is separated from the lubricating oil.
Cost is usually less due to simpler construction.	Costs more than two-cycle engine.

3. Method Used to Distinguish Between a Two and Four Cycle Engine

Check the operator's manual for crankcase capacity or the kind of oil to use. If the crankcase capacity is discussed, the engine is a four cycle. The mixing of oil and gas would identify the engine as a two cycle.

Check to see if the engine has an oil sump (place to add oil or a place to drain the oil). A four cycle engine has a sump; a two cycle does not.

Check to determine whether or not the engine has an exhaust muffler at the end of the cylinder, and if it does, it is a four cycle engine. The muffler is located in the center of the cylinder on a two cycle engine.

Check the compression by disconnecting the spark plug wire, mark the flange of the starter pulley and crank the engine by hand. On a four cycle engine, resistance is felt on every other revolution. Resistance is caused by compression on each revolution of a two cycle engine.

Transparencies Nos. 2 and 3

4. Types of Small Engines

a. Two Stroke Cycle Engines - The piston makes two strokes and the crankshaft turns one complete revolution in completing a cycle from power stroke to power stroke. Actually there are five events that take place. They include: intake, compression, ignition, expansion (power), and exhaust. All these events take place in two strokes of the piston.

As the piston moves upward, a partial vacuum is created in the crankcase. This causes the reed valve (valve between crankcase and carburetor) to open. An air-fuel mixture flows into the crankcase from the carburetor. As the piston moves down the air-fuel mixture is compressed in the crankcase. The reed valve is closed. Compressed air-fuel enters the cylinder through a by-pass port uncovered by the piston. This intake port is covered again as the piston moves upward to compress the air-fuel mixture in the cylinder and at the same time a new fuel charge is drawn into the crankcase.

Near the top of the compression stroke the fuel mixture is ignited forcing the piston down and creating a power stroke. The sudden expansion of the burning mixture causes this action. On this downward stroke most of the burned air-fuel mixture is exhausted as the piston nears the bottom of the cylinder.

b. Four Stroke Cycle Engines - There are two complete revolutions of the crankshaft for each power stroke of the piston or a complete cycle of the engine. A complete cycle consists of the following four strokes in the cylinder:

(1) Intake - As the piston moves downward, a partial vacuum is created in the cylinder. A mixture of vaporized fuel and air is forced into the cylinder from outside air pressure through the intake valve. The exhaust valve is closed.

(2) Compression - Both intake and exhaust valves are closed during this stroke. The upward movement of the piston compresses the air-fuel mixture between the piston top and cylinder head.

(3) Power - Both valves remain closed on this stroke. The fuel-air mixture is ignited by an electrical spark which causes an explosion in the cylinder and forcing the piston down. This downward movement delivers power to the crankshaft.

(4) Exhaust - As the piston moves upward, burned gases are forced out of the cylinder through the open exhaust valve. This valve closes at the end of the stroke and the intake valve opens as the next cycle begins.

Transparency No. 4

5. General Compression Information

In order for the fuel-air mixture to be compressed by the piston in the top of the cylinder, no leakage must appear between the piston and cylinder wall. Compression rings are fitted in a groove near the top of the piston so that they may serve the following functions:

Exert pressure on the cylinder wall to compress the fuel-air mixture in a small space.

Scrape the oil back into the crankcase and away from the combustion chamber to keep it from being burned.

Each cylinder has a perforated oil ring located below the compression ring or rings. The perforations permit the oil to be spread evenly on the cylinder wall. The amount of fuel-air mixture to be compressed in a cylinder depends on the piston displacement (space displaced by the piston in its up and down travel). The area of displacement depends on the size of bore and the length of stroke. The following formula is used to compute piston displacement in cubic

inches:

$$\text{Piston displacement} = \frac{(\text{bore})^2}{4} \times \pi \times \text{stroke}$$

Example of a 2 inch bore and a 1 3/4 inch stroke:

$$\frac{2 \times 2}{4} \times 3.1416 \times 1\ 3/4 = 5.5 \text{ cubic inches piston displacement}$$

Most small engines vary from 5: 1 to 6: 1 compression ratio. The ratio is a good comparison of the cylinder area, when the piston is at the bottom and at the top of the stroke. Generally, an engine with a high compression ratio has more power than one with low compression.

References:

1. Stephenson, George E., Small Gasoline Engines, Delmar Publishers, Albany, New York, 1973

2. "Small Engines, Volume I", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

3. "General Theories of Operation", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1971

4. "Small Engines - Principles of Operation, Trouble Shooting, and Tune-Up", University of Illinois, Urbana, Illinois, 1970

5. "The Two Cycle Engine", University of Illinois, Urbana, Illinois, 1970

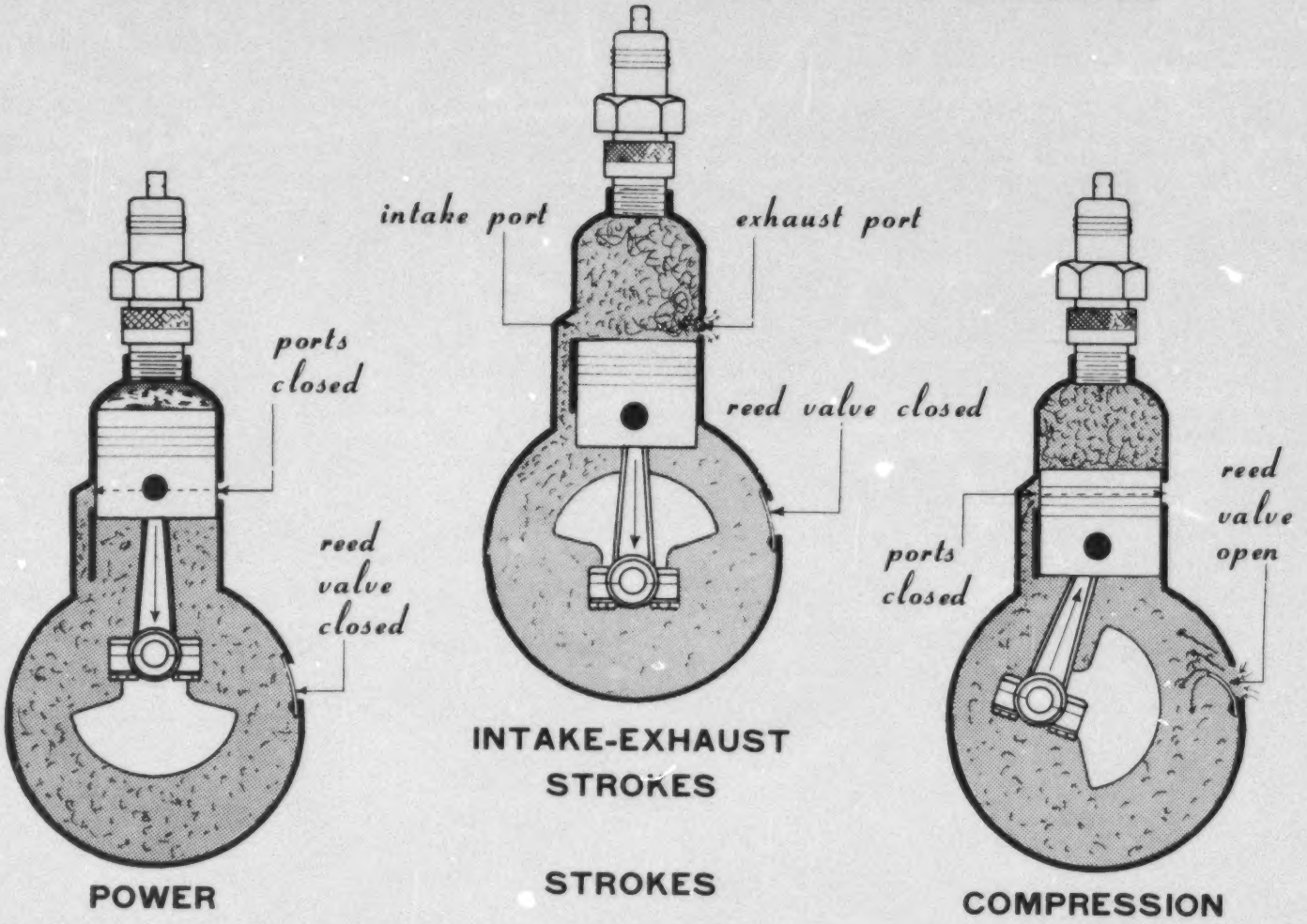
WHY SMALL ENGINES ARE ADAPTABLE TO MANY KINDS OF JOBS

- LIGHTWEIGHT
- PORTABLE
- ECONOMICAL ON FUEL USE
- AIR-COOLED
- COMPACT
- EASY TO SERVICE
- SOURCE OF POWER FOR SMALL EQUIPMENT

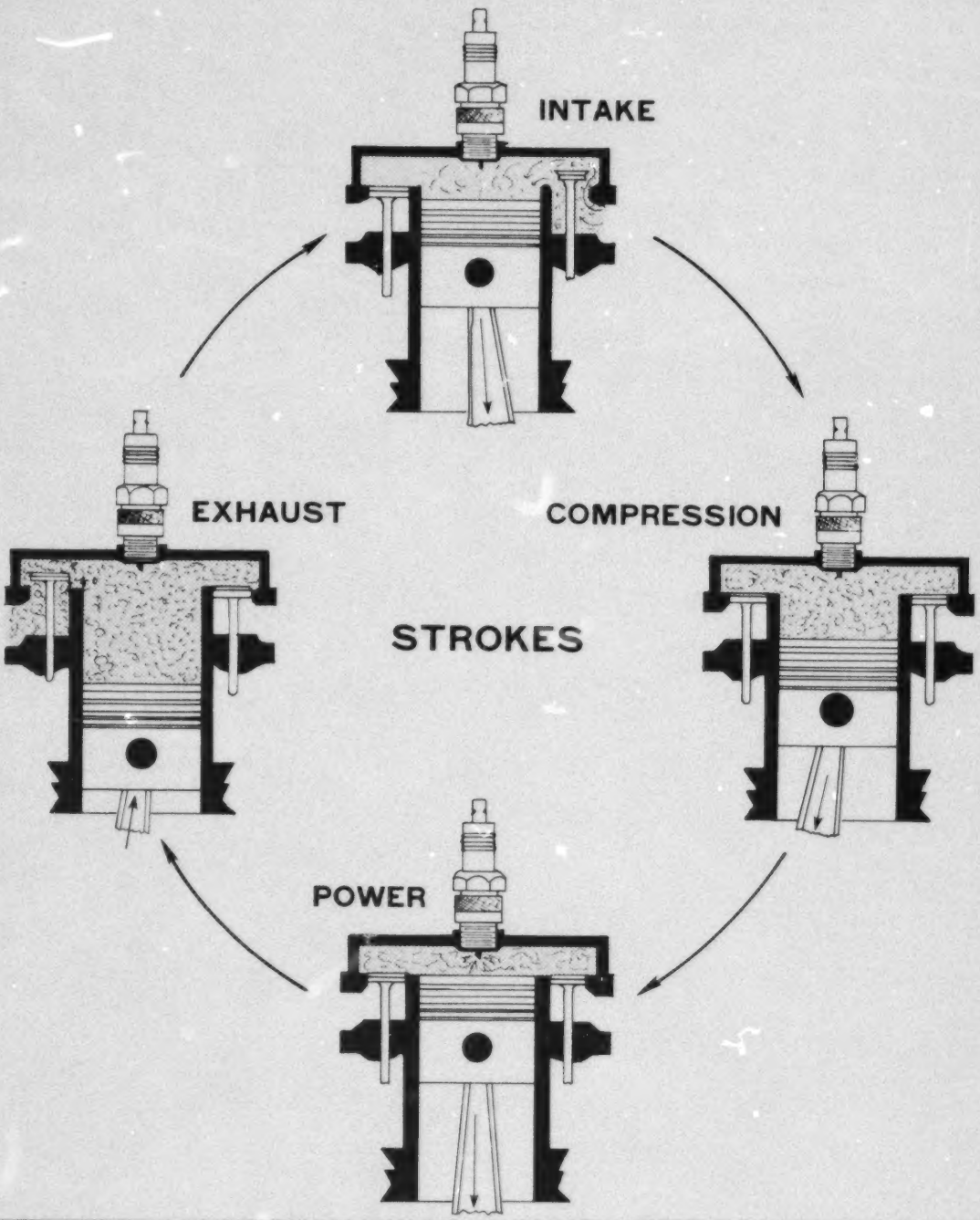
EQUIPMENT POWERED BY SMALL ENGINES

- MOWERS
- BRUSH CUTTERS
- CHAIN SAWS
- ROTARY TILLERS
- CONVEYORS
- IRRIGATION PUMPS
- ELEVATORS
- SPRAYERS
- POST HOLE DIGGERS
- CONCRETE VIBRATORS
- SMALL FEED GRINDERS
- GENERATORS
- CONCRETE SURFACERS
- OUTBOARD BOATS
- AIR COMPRESSORS
- SMALL TRACTORS

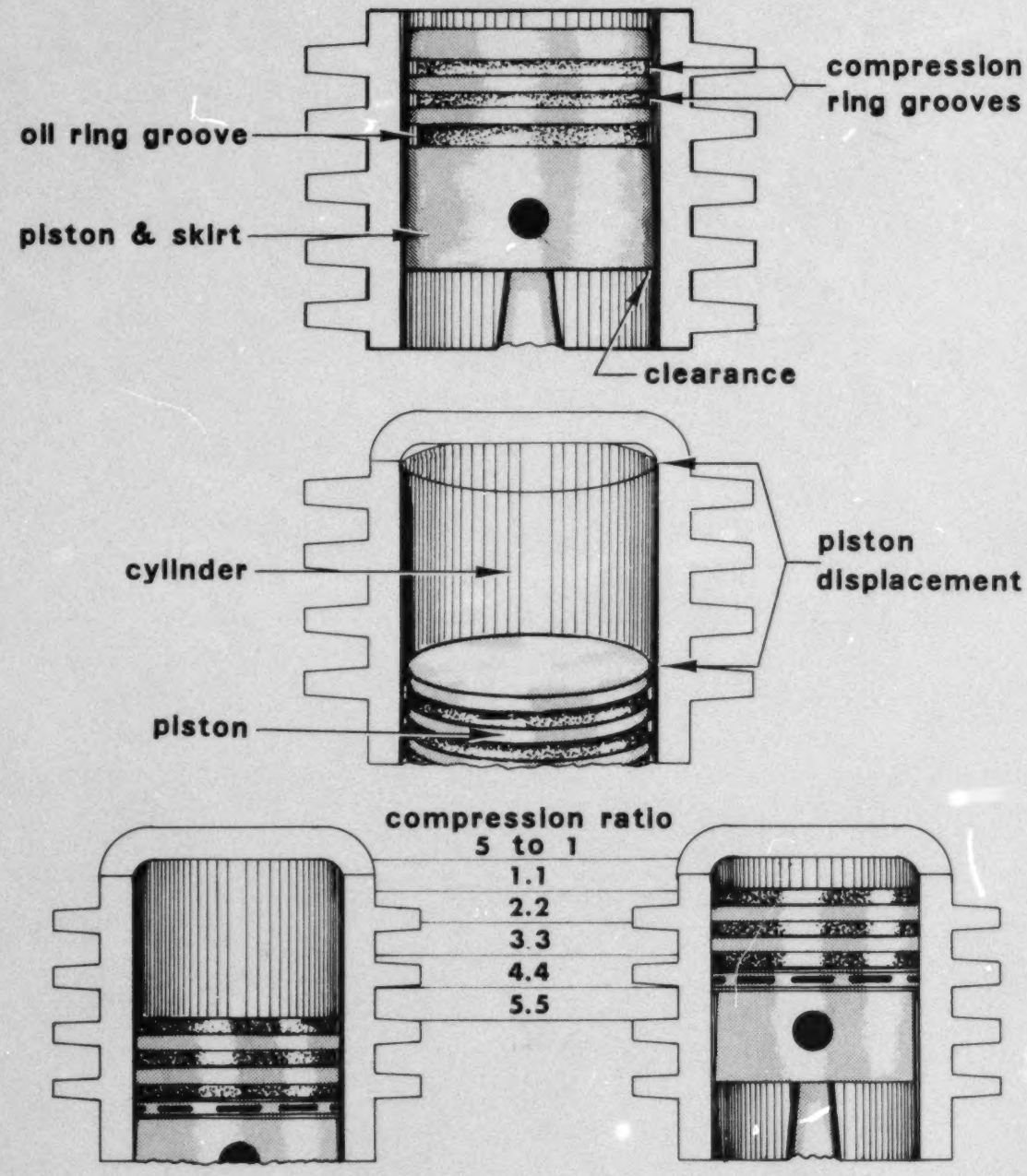
OPERATION OF A TWO-CYCLE ENGINE



OPERATION OF A FOUR-CYCLE ENGINE



PISTON CLEARANCE, DISPLACEMENT, AND RATIO



FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A: Small Gasoline Engines

Topic 2: Disassembly and Reassembly of the Small Engine

Suggested Procedures and Activities: The use or presenting the parts of a partially disassembled engine can be very helpful when explaining the information found in this topic.

1. Introduction

Preventive maintenance for small engines is similar to that for larger engines. Maintenance practices such as periodic oil level checks, spark plug inspection, keeping the engine clean and changing oil as recommended by the service manual are necessary for long engine life. Normal wear will eventually cause many moving parts to be replaced or normal wear will cause a complete overhaul. Small engines may be reconditioned at a reasonable cost if proper tools are available. In some cases it may be more economical to buy a new engine than to pay for a complete overhaul.

If a small engine is to have a useful and prolonged life, it is very important that the recommendation be followed in the operator's manual.

Transparency No. 1

2. How to Clean an Engine

The engine should be thoroughly cleaned before it is disassembled. The steps in cleaning are:

a. Dry dirt should be loosened with a stiff brush and putty knife.

b. Blow loose dirt and other foreign material off the engine with an air hose, but avoid getting dirt into internal parts of the engine.

c. Use solvent and rags to remove oil and grease. It is unsafe to use gasoline as a solvent. Remove air deflectors, cylinder baffles, and blower shroud in order to make the cleaning easier.

Transparencies Nos. 1 and 2

3. Disassembling a Small Engine

Due to the many different makes (brand names), models, and types of small engines, the general steps used to disassemble small engines may vary. However, there are general steps that may be used to disassemble most engines. A general procedure is as follows:

a. Preparing the engine for disassembly involves several important steps.

(1) Remove gasoline or fuel mixture from the fuel tank, fuel lines, and carburetor. If fuel is to be reused it must be stored in a clean and dry container.

(2) Drain the crankcase by removing the drain plug. Oil will flow more freely if it is warm; therefore, if the engine will start it should be started and operated long enough to heat the oil. The oil pump can be cleaned after it is removed from the engine. Dispose of used oil.

(3) Remove the air cleaner assembly (stud, wing nut, and clamp). Drain oil from the oil bath type cleaner and discard. Any type of air cleaner (oil bath or dry) should be set aside for servicing.

b. After the engine has been cleaned and fuel and oil removed it should be ready to disassemble. But, first prepare an information sheet to record important data about damaged or broken parts as the engine is being disassembled. The disassembly procedure may be as follows:

(1) Remove the spark plug by using a spark plug socket wrench. This type of wrench is cushioned to protect the porcelain part of the plug. The gap and condition of electrode may be checked and recorded. A compression reading and spark output test may be taken at this point.

(2) Disconnect the governor link. The governor spring should be removed without excessive stretching so the link will not be distorted. In order to reconnect the governor, throttle, throttle linkage, and other fuel connections, check the operator's manual to determine whether or not assembly information is available. If this information is not available, make sketches before removing the linkage.

(3) Disconnect the fuel supply lines and carburetor. If the engine has a gravity flow type system, remove the fuel tank and then disconnect the carburetor from the tank and engine. If the engine has a suction

system, remove the tank and carburetor together.

(4) Use penetrating oil on muffler threads and remove the muffler if it is to be replaced; otherwise, leave it attached to the engine.

(5) After the engine has been removed from its mounting (equipment), remove the starter. The method used to remove the starter will depend on the type of starter connected to the engine. Some starters are fastened to the flywheel housing by three or four bolts. A certain type of starter may be located in the flywheel housing. It may be necessary to remove the cowling on some makes of engines before removing the starter.

If the manual recoil starter is to be disassembled, it should be placed in a vise or secured by C-clamps before working on it. The rope can be removed by pulling it all the way out and locking the starter in place with vise-grip pliers. If the spring is removed, the starter may be rewound by a screwdriver or special rewinding tool. The two most popular types of manual starters are the rope-wind and the windup. Both types have a recoil spring. Some small engines are equipped with regular starter motors that operate off batteries, the same as automobiles. Less common are 120-volt alternating-current starting motors for small engines.

Transparencies Nos. 3, 4, and 5

c. Disassembly of the main body of the engine and its parts:

(1) Remove the valve chamber cover, cylinder head, and gasket. It may facilitate reassembly if the bolts are marked as they are taken from the cylinder head. Some head bolts are longer than others and serve purposes other than holding the head in place. The bore and stroke can be measured at this stage of disassembly.

(2) Check the flywheel shaft to determine whether the shaft is threaded right or left handed. This is accomplished before removing the nut. Remove the protective screen if one is mounted on the flywheel assembly.

The flywheel may be removed by using a special holder or wood blocks and a heavy duty socket wrench. If screwdrivers or wrecking bars are used as a holder, it is possible the fins will be damaged, throwing the flywheel out of balance. The socket wrench handle should be tapped lightly with a soft mallet to loosen the nut.

If the shaft is tapered and the flywheel is secured by a key, it may be

removed by holding the engine in place about two inches from the work table and tapping the shaft with a lead hammer or striking a hardwood block placed on the shaft. An impact nut on the end of the shaft will protect the threads. A special wheel puller may also be used to remove a flywheel mounted on a standard shaft. It may be appropriate to remove the ignition at this point during the disassembling operation. Most magneto systems are located back of the flywheel shroud. On some engines the magnets are cast into the flywheel and cannot be removed. Some of the larger engines are equipped with starter-generators or alternators which must be removed.

(3) Open the crankcase on four-cycle engines by removing the oil sump or PTD plate. Remove the rod-bearing access plate or the carburetor or reed plate on two-cycle engines. Engines with ball bearings supporting the crankshaft have grease seals and locking nuts that must be removed before the engine side can be removed. Engines with sleeves around the crankshaft may not be sealed in the same manner as ball bearings. Pry out the seal with a sharp tool and remove locking nuts and bearings. Before removing the side or oil sump of an engine to expose the crankshaft, rough places may be corrected on the exposed ends.

Open the crankcase without disassembling the cam gear. Most timing gears have timing marks. If the marks are not visible, make them visible by using a center punch before unmeshing the gears. Some engines have alignment dowels that must be removed before opening the engine.

(4) Remove the cap screws from the bearing cap. Push the piston and rod out through the top of the engine if the engine head is removable. If the cylinder head is not removable, the piston assembly must be removed from the bottom, which means that the crankshaft must be removed. Before removing the piston, it may be advisable to move the piston to the bottom dead center position and examine the upper end of the cylinder for a sharp ridge. If a ridge is present, remove it with a ridge reamer before pushing the piston through the top.

(5) If a cylinder does not require reboring, disassemble the piston and rod assembly in the following order:

(a) Remove the piston retainer rings that are located on each end of the piston pin.
(b) Use a piston ring expander to remove the rings. Rings can be removed by using a small screwdriver or long-nose pliers.

(c) As the rings are removed, place them in order and the proper side up so they may be replaced in the proper grooves.

(6) Valves are easier to remove if a valve-spring compressor is used to press the springs before trying to remove the valve retainer. The valve should be held closed with the hand if it is removed by using a screwdriver. Remove the retainer lock with pliers or a screwdriver or pliers depending upon the type of retainer lock.

Remove the valves and mark them exhaust or intake. If the springs and caps are removed they should be marked so they may be placed in the proper valve hole.

If burrs are found on the valve stem, they should be removed with a file before forcing the valve through the opening.

Two-cycle engines have a reed valve or the piston serves as a sliding valve. The reed valve is usually not removed unless it is necessary to replace it.

(7) Remove the camshaft by removing the gear cover or base plate, that is, if the engine has a vertical crankshaft or does not have an oil sump. Mark the crankshaft and the cam gear.

The crankshaft should be turned so that the timing marks are aligned on the compression stroke. Both valves should be closed. Pressure from the tappets is relieved by this action. The tappets will remain in place while removing the camshaft if the crankcase is turned on its side or placed upside down. Mark the valve tappets and remove them one at a time. The tappets should be reinserted in the same holes from which they came.

(8) Remove the retaining rings on each end of the crankshaft if rings are part of the unit, and remove the tapered roller bearing shaft by hand. The nontapered bearing type must be tapped or pressed out. Naturally, the seals should be removed during this operation. On some engines the crankshaft is removed from the housing before removing the bearing plate.

Transparency No. 6

4. Reassembling Engine Parts

a. Replace the bearing on the crankshaft by heating it in oil and slipping the bearing on the crankshaft while it is still hot. As the metal cools, the bearing will tighten on the shaft.

b. In many four-cycle engines that are made of aluminum alloy, the tappets are oiled and installed in the order they were removed. After the tappets are replaced, the crankshaft and the cam gear are installed. The timing marks on the crankshaft and cam gears must be aligned. In cast iron engines the tappets are attached to the cylinder and then the cam gear is installed.

c. Clean the cylinder walls with an oil soaked rag. Check the ring gap and install rings in the correct position on the piston. Use a ring compressor to install the rings.

Install the oil ring and then the compression rings. The center ring may have a scraper groove; therefore, it must be installed with the scraper groove down. If the top rings have a recess, the recess goes up. Attach the connecting rod to the piston. The piston and rod may be marked to identify rod and piston alignment. Some two-cycle engines have pistons with a small pin or knob to prevent the ring from turning. They must be installed properly.

Check the ring gap and groove with a feeler gauge. Insert the piston in the cylinder so that the connecting rod is in contact with the block. Use a ring compressor to squeeze the rings into the grooves. Push the piston into the cylinder.

Oil all parts and put on the bearing cap. Tighten the bearing bolts with a torque wrench, using about 90 inch-pounds. If the engine turns freely, the bolts should be locked. If an engine does not turn freely, the piston should be checked to determine whether or not they were installed backwards.

d. After the valves have been refaced and seated properly they should be replaced in the engine. Use a feeler gauge to check valve-tappet clearance. The valve springs and keepers should be replaced by using the spring compressor and pin inserter. Needle nose pliers can be used to insert the pin. Turn the engine several times to be sure the valves are opening and closing properly.

e. The engine head should be replaced after the valves are installed and seated. Use a new head gasket between the head and cylinder. The head bolts should be drawn up evenly with a socket wrench and the final tightening should be done with a torque wrench. The bolts should be tightened evenly, alternating the tightened bolts from one side to the other.

5. Replacing Other Major Parts of the Engine

Other major parts may be assembled in the following order:

Spark plugs
Starter pulley or clutch
Governor blade
Breather assembly
Muffler and fuel tank
Carburetor and linkage (align pneumatic governor)
Blower housing
Fuel line

6. Operation Steps

a. Refill crankcase (4-cycle engine) with the proper oil.

b. Refill the oil bath air cleaner (if this part is on the engine) with clean oil.

c. Use a proper fuel mixture (2-cycle engine) to fill the fuel tank.

d. Adjust main jet valve on carburetor so engine will run smoothly.

e. Hold the throttle shut and adjust idle speed so engine operates smoothly.

f. Set the idle speed by adjusting the idle screw.

g. After the engine has operated a few minutes, adjust the carburetor so that the engine will accelerate at different speeds.

The head bolts should be retightened with a torque wrench after about 10 hours of operation. It may necessary to readjust the carburetor after the engine has been in operation about 10 hours.

References:

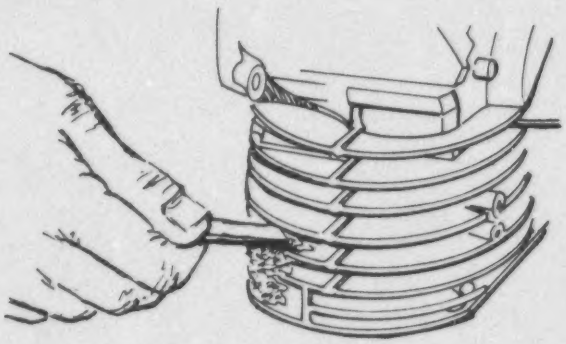
1. "Small Engines - Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1974

2. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1977

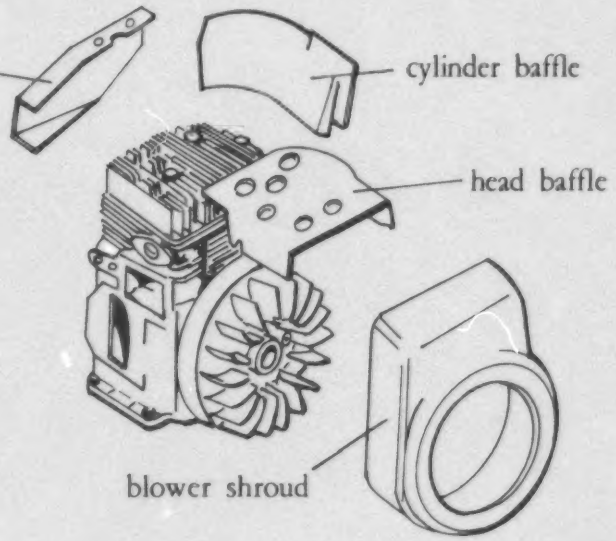
3. "Small Engines Service Manual", Intertec Publishing Corporation, Kansas City, Missouri, 1976

4. "Small Engines - Repair and Overhaul", University of Illinois, Urbana, Illinois, 1970

DISASSEMBLING ENGINE

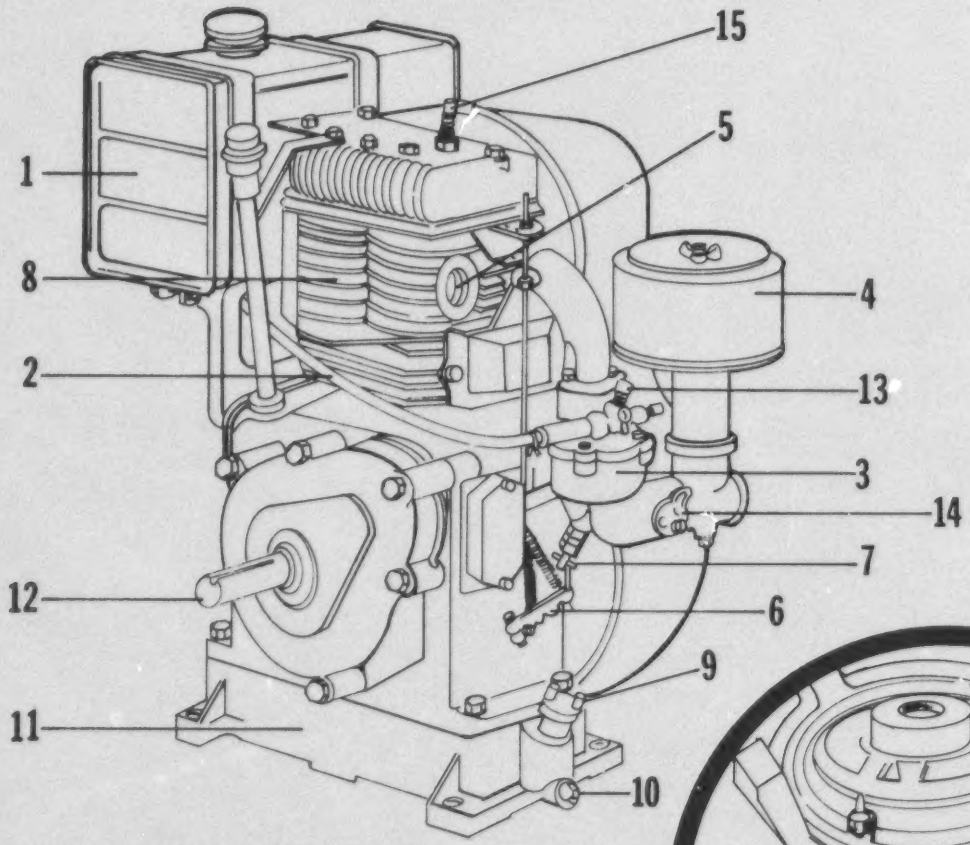


USING SOFT SCRAPER ON CYLINDER HEAD FINS



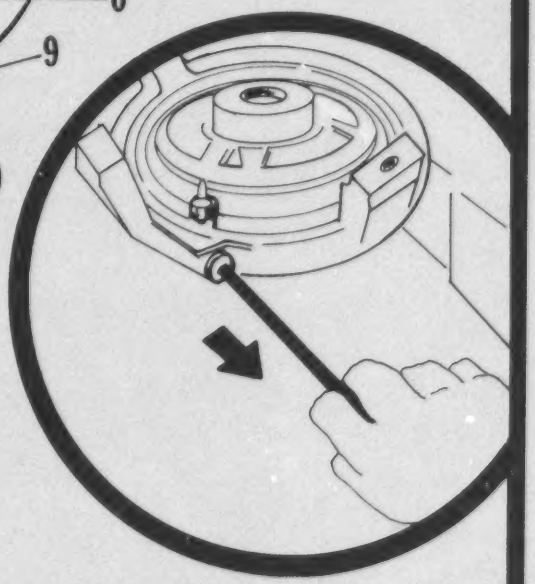
ENGINE COWLING

SMALL ENGINES



MAJOR ENGINE PARTS

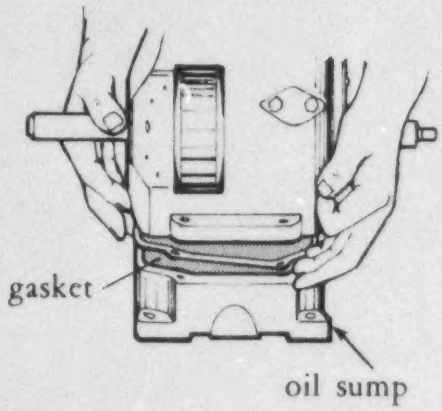
1. Fuel Tank
2. Fuel Line
3. Carburetor
4. Air Cleaner
5. Muffler
6. Speed Control Lever
7. High Speed Adjustment
8. Cylinder Head
9. Oil Filter Plug
10. Oil Drain Plug
11. Oil Sump
12. Power Shaft
13. Idle Screw
14. Choke Lever
15. Spark Plug

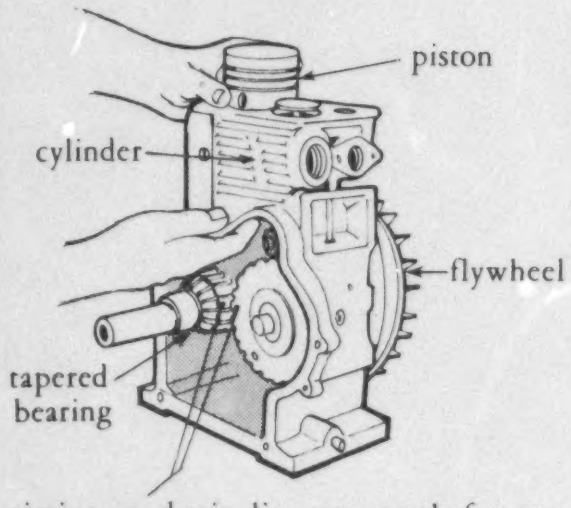


RECOIL STARTER

DISASSEMBLING ENGINE

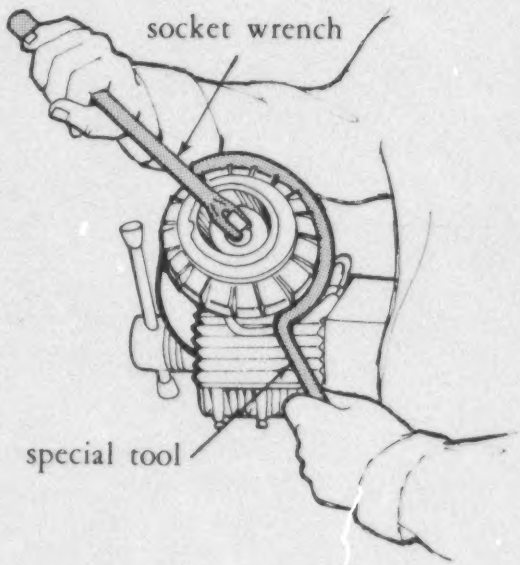
OPENING ENGINE

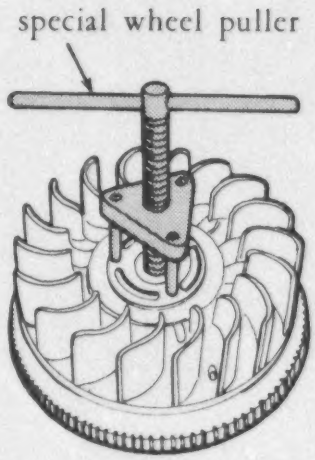




timing marks in line on camshaft gears

REMOVING FLYWHEEL





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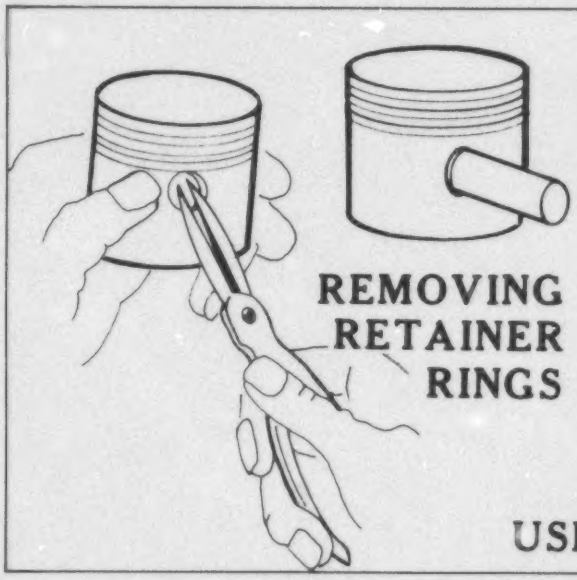
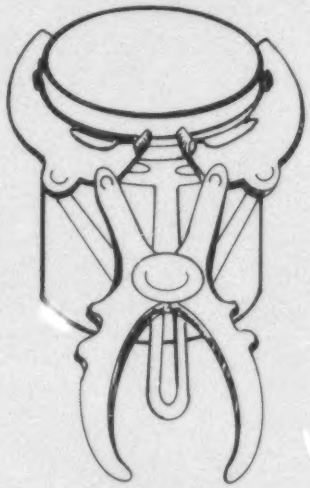
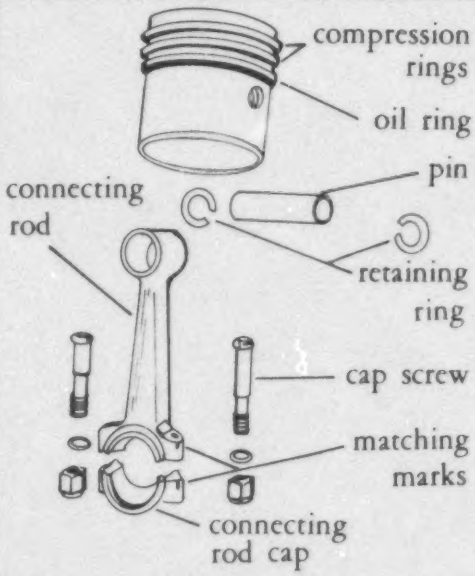


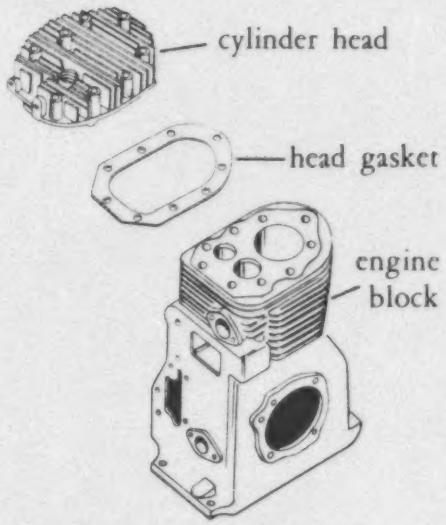
REMOVING RETAINER RINGS



USING RING EXPANDER

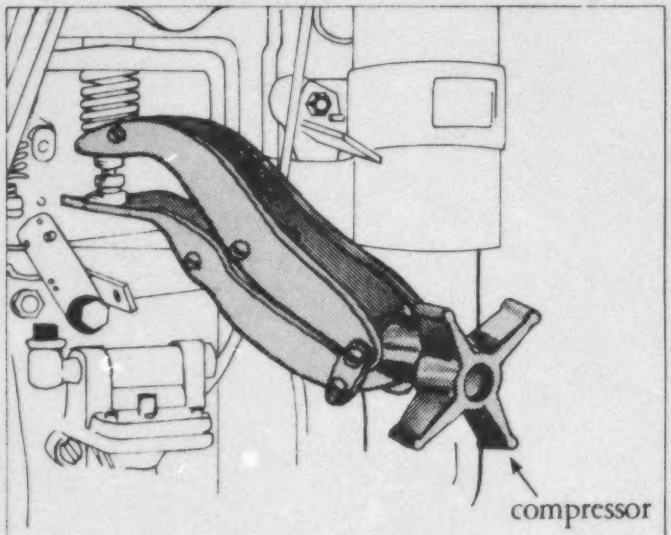


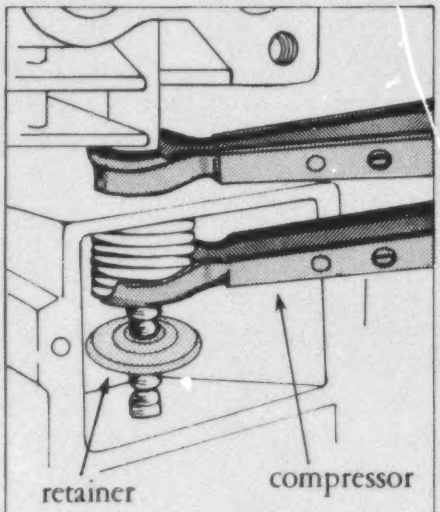
PISTON ASSEMBLY



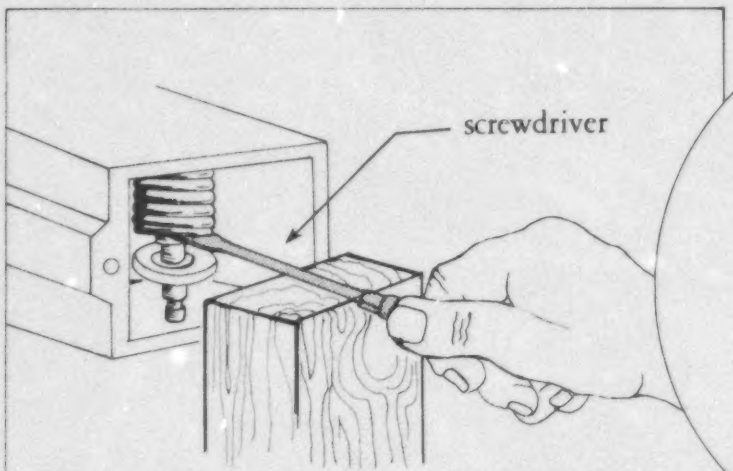
BLOCK AND HEAD UNIT

DISASSEMBLING ENGINE



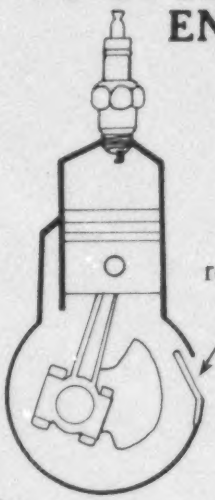


VALVE SPRING COMPRESSORS

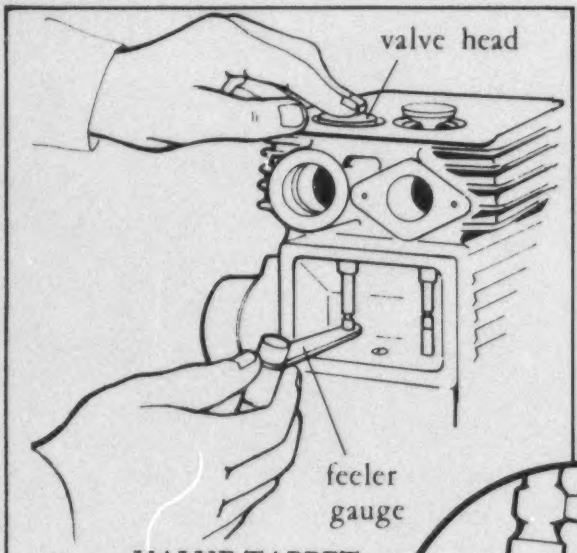


SCREWDRIVER AS SPRING COMPRESSOR

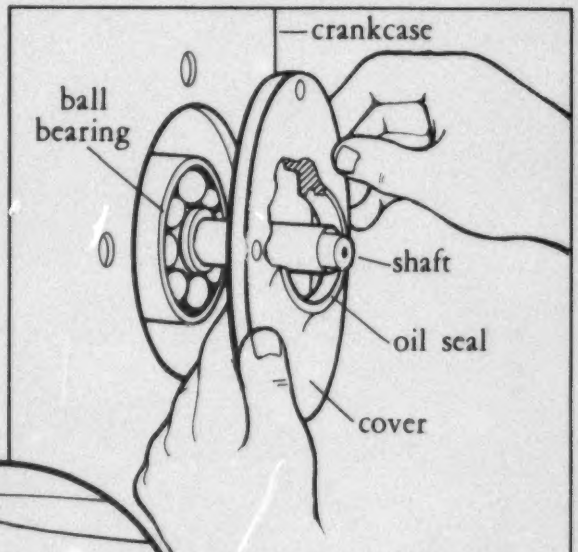
TWO-CYCLE ENGINE



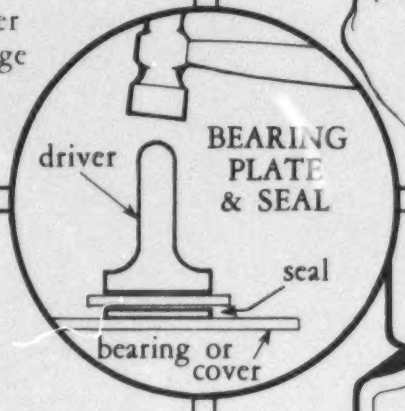
REASSEMBLING ENGINE

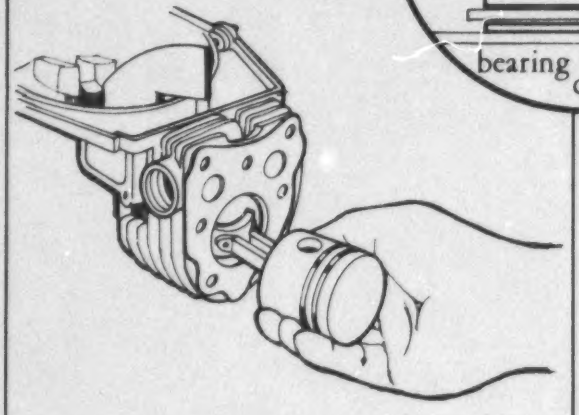


VALVE-TAPPET CLEARANCE

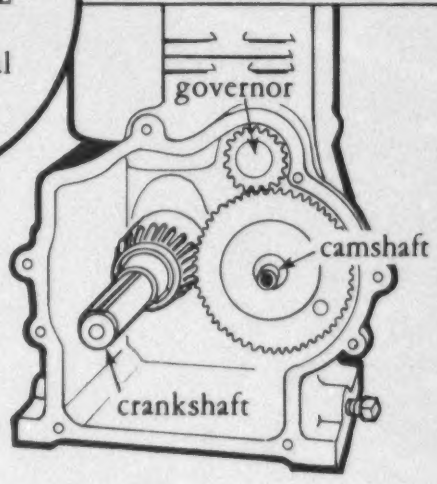


INSTALLING PLATE





INSTALLING ROD & PISTON IN CYLINDER



CAMSHAFT, CRANKSHAFT & GOVERNOR INSTALLED

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A: Small Gasoline Engines

Topic 3: Checking and Adjusting the Carburetor

Suggested Procedures and Activities: The use of two carburetors, one assembled and one disassembled, will serve as excellent teaching aids during the class discussion.

1. The Purpose of the Carburetor

The major function of the carburetor is to atomize fuel (reduce to fine spray), mix air with the fuel, vaporize the fuel, and deliver the mixture to the combustion chamber (that portion of the cylinder where fuel is burned). Usually the fuel-air ratio is considered to be 14 to 15 parts of air by weight to one part of gasoline. Carburetion function is basically the same in two cycle and four cycle engines, in that air is mixed with fuel to form a combustible mixture. The reason that air and atomized fuel flows into a cylinder or crankcase is the difference in the cylinder or crankcase pressure and the outside atmospheric pressure.

Transparency No. 1

2. The Basic Parts of A Carburetor and Their Functions

a. Butterfly or Throttle - The amount of fuel mixture entering the cylinder (combustion chamber) is controlled by the throttle. The amount of mixture admitted determines the engine speed. The throttle also allows the engine to accelerate smoothly from low to high speed.

b. Venturi - The main function of the venturi (narrow part of throttle pipe where accelerated air moves through the carburetor causing fuel to be drawn through the nozzle and atomized) is to increase the velocity of incoming air. Low pressure is created at the fuel nozzle discharge holes due to the high velocity air flow. The atomizing of fuel and mixing with air takes place in the venturi.

c. Choke - The purpose of the choke is to control the air flow in the carburetor. With the choke closed, the air is cut off or greatly reduced and the fuel mixture becomes rich (higher percent of gasoline). A rich mixture ignites and burns readily in a cold engine.

d. Needle Valve - This valve meters the amount of fuel used at operating speed. It also controls the amount of fuel in the carburetor. It is considered to be the high-speed air-fuel mixture adjusting valve. In carburetors that have no needle valve adjustments, the valve is preset by the manufacturer.

e. Idle Valve - This valve adjusts the fuel for slow or idle speeds. It is usually located in the low pressure area of the carburetor (carburetor throat beyond the throttle plate). On some carburetors, idle or slow speed is controlled by a slow-speed-needle valve.

f. Float - A constant fuel or gasoline level is maintained in the carburetor by a float and float bowl. The suction and diaphragm type carburetors are not equipped with a float and float bowl. The float actually controls the flow of fuel from the tank to the carburetor.

Transparency No. 2

3. Methods of Supplying Fuel to the Carburetor

a. Gravity System - The fuel tank is located above the carburetor, thus permitting the fuel to flow by gravity into the carburetor bowl. The float controls the amount of fuel entering the float bowl or float chamber.

b. Suction System - Fuel is drawn from the tank through a tube that is located below the carburetor. The suction created by the engine pulls gasoline from the fuel tank, and a foot valve keeps the fuel from returning to the tank. This insures a tank full of fuel at all times. There are certain types of carburetors with built-in fuel pumps which operate on pressure change within the carburetor. This system is usually found on economy priced equipment.

c. Fuel Pump - The fuel tank on this system is usually mounted at a lower level than a carburetor. The pump pulls the gasoline from the tank and forces it through lines to the carburetor. The fuel pump system is usually more costly than gravity or suction system.

d. Pressurized System - This system is usually found on outboard engines. Fuel can be forced through lines a long distance to the carburetor. There are two lines from the fuel tank to the engine. One line carries gasoline or fuel, and the other carries air from the crankcase to the tank. The fuel tank must be a pressure type for this system to operate.

4. Disassembling, Assembling, and Adjusting an Engine Carburetor

a. Disassembling the Carburetor - The following procedure may be used in disassembling a carburetor:

(1) Use a stiff brush and/ or a putty knife to loosen dirt on and around the carburetor. Use an air hose to blow loose dirt and other foreign material from the carburetor and surrounding area. Remove oil and grease by using a solvent and rags. Do not use gasoline as a solvent.

(2) Drain the fuel from the tank and carburetor. If the fuel is perfectly clean, it may be reused.

(3) If an operator's manual is not available or fails to show throttle linkage and carburetor connections, make sketches of the linkage before disassembling. Governor and throttle connections must be reconnected properly.

(4) Use the following procedure to disassemble the float-type carburetor:

(a) Remove the main fuel jet if it is diagonally installed on the side of the carburetor. This jet should be removed before separating the two halves of the carburetor. Use a proper size screwdriver on the main fuel jet (nozzle).
(b) Remove the needle valve by loosening the valve and nut together.
(c) Remove the section bolts of the carburetor together. Mark the gasket(s) so that a new one may be replaced properly.
(d) Pull the pin from the float hinge and remove the float valve. Also remove the idle mixture valve.

If the engine is supplied with a diaphragm-type carburetor, disassemble it in a similar manner as the float-type carburetor. The fuel pump is usually built in this type of carburetor. In disassembling the diaphragm-type carburetor, the diaphragm is removed from the main body of the carburetor.
(e) If necessary remove the choke valve and butterfly from the carburetor.

(5) Disassemble the suction-type carburetor by using the following procedure:

(a) Remove the carburetor from the tank. The broad and shallow tank may resemble a carburetor bowl.

(b) Place the fuel pipe in a vise and pry it out of the carburetor body.

(c) If adjusting needles are present in the suction-lift carburetor, remove them.

After the carburetor has been disassembled, clean all parts with a gum solvent or lacquer thinner. Parts made from synthetics such as nylon should not be soaked for more than 30 minutes. Other parts may remain in a solvent (Bendix, petisol or thinner) for several hours. The engine may be disassembled during the time the carburetor is soaking.

b. After all parts of the carburetor have been cleaned and checked for wear, reassemble in reverse order of disassembly. An examination should be made of the following parts before the carburetor is reassembled:

(1) Needle Valve(s) - If the valve has a worn ring or rim, it should be replaced by a new one with new seats.

(2) Float - The float should be checked for leakage or damage.

(3) Throttle Shaft - The bushing should be replaced if the wear is more than .010 inches.

(4) Fuel Jet - The fuel jets should be cleaned, and if it appears to be damaged, it should be replaced.

(5) Gaskets - All new gaskets should be used when reassembling the carburetor.

There are many types of small engine carburetors. Generally the float-types are similar in design and the suction-types are similar. The suction-type has a built-in fuel pump. The two types of the float-type carburetor are one-piece and two-piece.

c. Carburetor adjustments are made at the factory for normal operation of the engine, but over a long period of usage it is necessary to readjust the carburetor. If the carburetor is reconditioned, it must be adjusted. It is very important that the main needle valve and idle valve be adjusted properly. If the mixture is too lean, the engine will miss and backfire, and if the mixture is too rich, the engine will operate sluggish and produce a heavy exhaust. The following procedure may be used to adjust the carburetor:

(1) Turn the main needle and idle valves clockwise with the fingers until they are tight. Do not use excessive force. Then open the

main needle valve one turn. Also turn the idle valve counter-clockwise to open, but make 3/4 turn.

(2) Use the choke and start the engine. Allow it to reach the normal operating temperature.

(3) Operate the engine at normal operating speed, which is about 2/3 full throttle. Turn the main needle valve clockwise until the engine begins to stall or slow down. This means the mixture is too thin. Then turn the main needle valve counterclockwise until the engine begins to stall or slow down again. This needle position means the mixture is too rich. Turn the needle clock-wise again to set the needle valve between the rich and lean positions. The engine should operate smoothly.

(4) Adjust the idle valve by turning it clockwise until the engine begins to reduce speed. Then turn counterclockwise until the idle speed is smooth, caused by increased speed of the engine. Set the idle screw at the desired speed. The idle speed can be checked with a tachometer. The idle speed may be considered about one-half the maximum operating speed.

(5) Open the throttle rapidly to check the acceleration. If the engine seems sluggish, turn the main needle valve to give a richer fuel mixture. At this point it may be necessary to adjust the idle speed stop screw. It is adjusted to hold the throttle at the proper speed.

References:

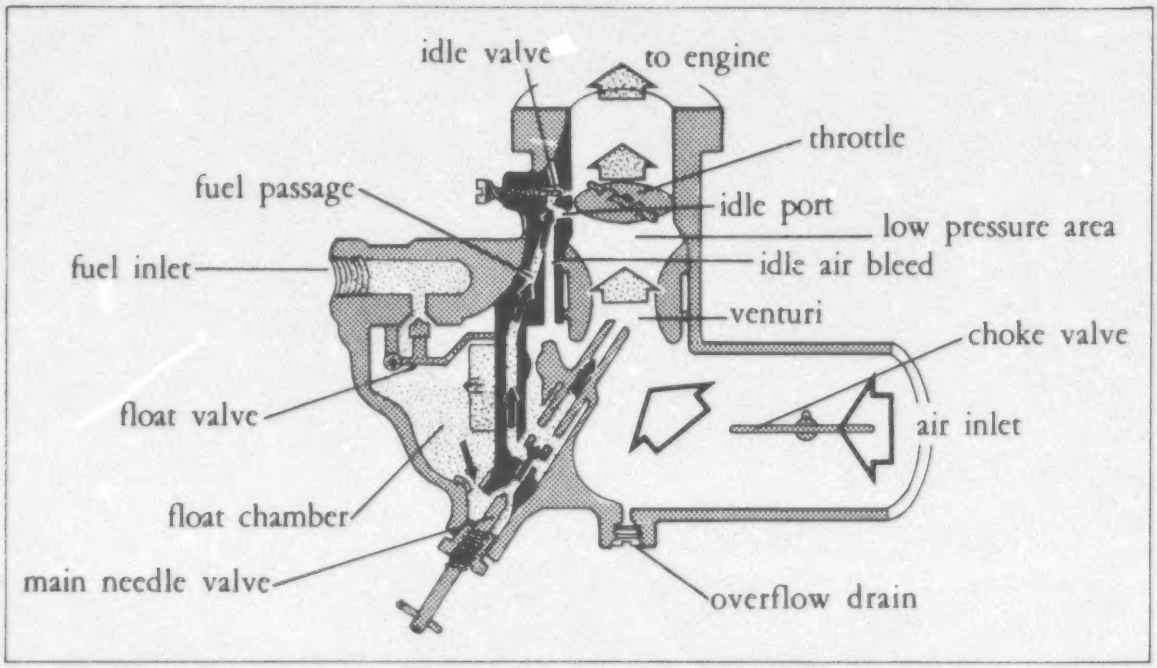
1. Stephenson, George E., Small Gasoline Engines, Delmar Publishers, Albany, New York, 1973

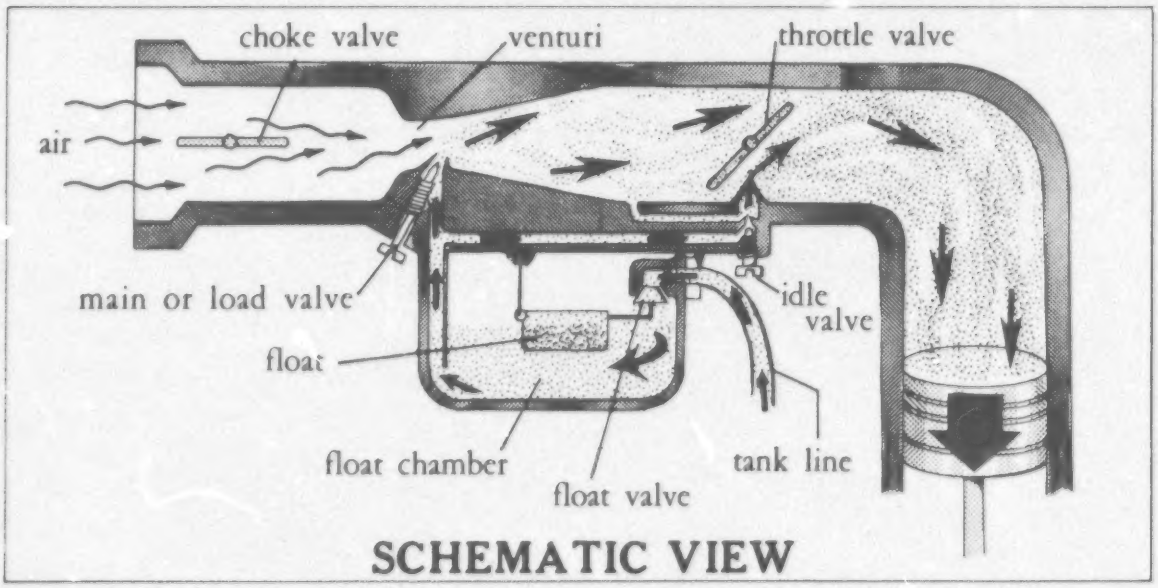
2. "Small Engines - Care and Operation, Volume I", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

3. "Small Gasoline Engine - Float-Type Carburetor Repair", State Department of Education, Columbia, South Carolina, 1973

4. "Small Engines - Repair and Overhaul", University of Illinois, Urbana, Illinois, 1970

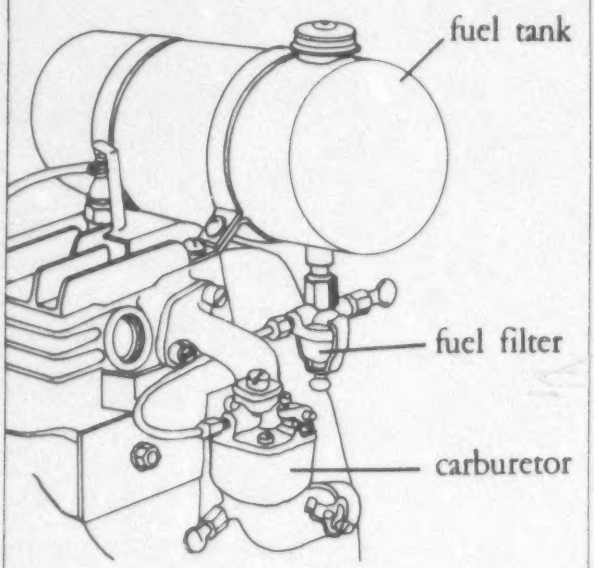
FLOAT TYPE CARBURETOR



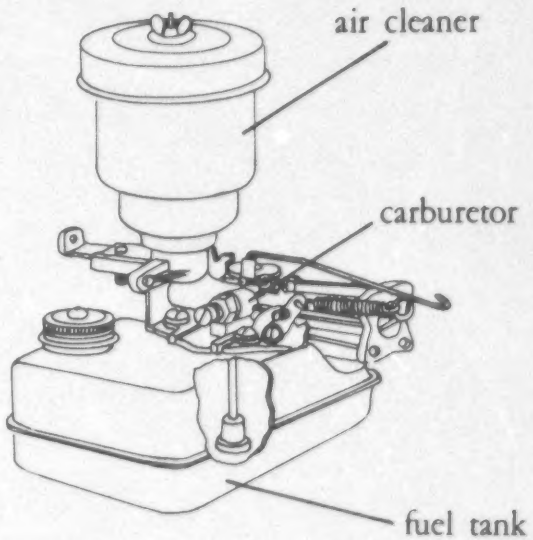


SCHEMATIC VIEW

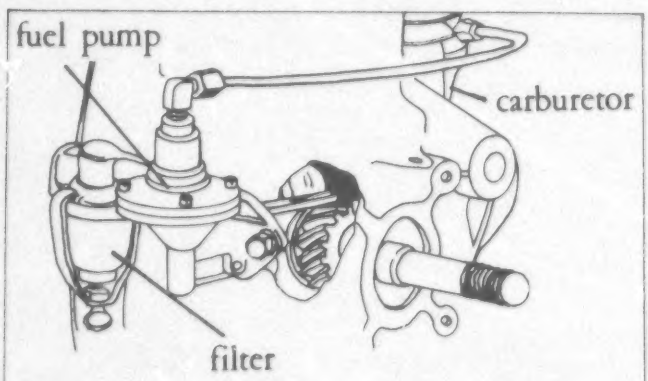
FUEL SUPPLYING METHODS



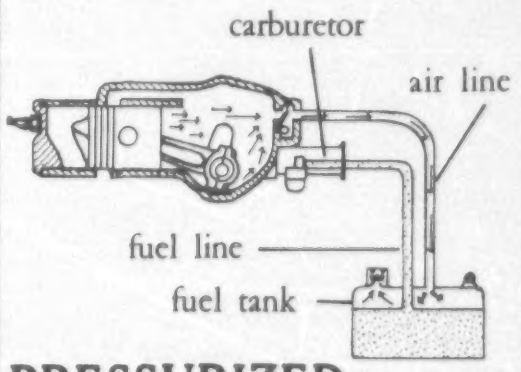
GRAVITY SYSTEM



SUCTION SYSTEM



FUEL PUMP SYSTEM



PRESSURIZED SYSTEM

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A: Small Gasoline Engines

Topic 4: Checking and Adjusting the Governor

Suggested Procedures and Activities: The operation principles of both the air-vane and centrifugal type governor can be demonstrated by using the governors as teaching aids mounted on the engine and apart from the engine.

1. The Purpose of the Governor

The governor is a speed regulating device to prevent the small engine from either overspeeding or underspeeding. A properly regulated governor will cause the engine to maintain a constant speed with different loads. As the load increases, the governor opens the throttle valve, supplying more air-fuel mixture to maintain a constant speed. The opposite is true when the load is decreased. One part of the governor linkage is attached to the throttle valve, and the part may be located under the flywheel shroud (air-vane type) or on either end of the crankshaft in the crankcase (centrifugal type).

Transparency No. 1

2. Governors Used in Small Engines

a. Air-Vane Type - This governor is similar to the centrifugal type in that it will automatically adjust the flow of fuel to maintain a set speed. Many brands of small engines are equipped with this type of governor. When the engine is operating, air from the flywheel hits the air-vane, closing the throttle. An increase in speed is caused by an increase in spring tension, and decreasing the speed is caused by decreasing the spring tension on the governor assembly. The throttle is open on a stopped engine with this type of governor, because the air-vane is not pulling against the spring.

b. Centrifugal Type - The centrifugal type controls speed by the movement of a set of weights. These weights move outward at high speed and inward at low speed. The weights may be either flyball or flyweight types and spool. Outward rotation of the flyweights causes them to push against the spool, which rotates the arm. This causes more spring tension which

aids in closing the throttle. Another mechanical governor is the flyball type. It operates on the same principle as the flyweight governor. The steel balls move outward in the spring loaded raceways as the engine speed increases.

Transparency No. 2

3. Checking and Adjusting Governors

a. The following procedure may be used to check and adjust the engine governor:

(1) Check for worn or damaged linkage. A worn lever, link, spring, air-vane, and set screws should be replaced. Slightly damaged (bent) levers and air-vane may be straightened and used if movement is free and proper.

(2) Check the position of the throttle valve when the engine is stopped. The valve should be in the open position. It may be necessary to adjust the spring tension. This is usually done by releasing the tension.

(3) Check the engine speed by using a tachometer after the engine is allowed to warm up. Both no-load idle and high-idle speeds should be checked. The no-load idle speed should be checked with the throttle control in the closed position. The high-idle no-load speed rpm is checked with the throttle control in the open position. The speed should remain constant and at the rpm recommended in the operator's manual. High-idle speeds may vary on a four cycle engine from 2,000 to 3,600 rpm and the speeds for two cycle engines vary from about 2,000 to 5,000 rpm. If the engine surges or overspeeds at high-idle, the spring is usually too tight.

(4 Check the full-load engine speed by using a dynamometer if possible. Full-load speed may show 200 to 300 less rpm than high-idle no-load speed.

b. The different ways of adjusting governors include:

(1) Move the spring and/or link on the lever to reduce or increase spring tension. This changes the length of the throttle linkage.

(2) If the governor lever has no adjusting holes, loosen the clamp and rotate it upward or downward.

(3) Some governors are equipped with a throttle link resembling a heavy wire. Bend this link downward to increase speed or bend backward to decrease speed.

(4) On a governor that has a high speed screw, loosen the lock nut and move the screw inward or outward to adjust speed.

(5) Another type of governor control has a governor lever (flat piece of metal) that presses against the governor rod. The lever may be the type that fits into a yoke on one end of the crankshaft and controlled by a variable speed spring or it may be the type lever that is bolted to the casting. Both types press against the governor rod which controls the throttle shaft. To adjust the speed, bend this governor lever up or down.

(6) To adjust the flyweight type, relocate the collars on the shaft.

(7) If the governor is controlled by a lever, spring, and stud, reset the spring on the lever or adjust the stud bolt and nuts for more or less spring tension.

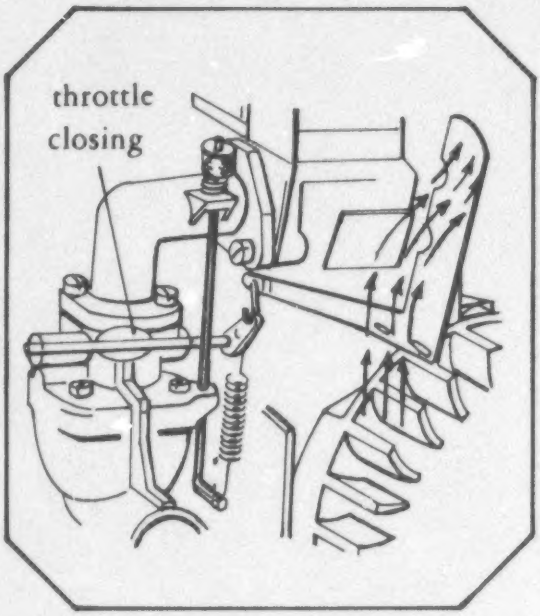
References:

1. "Small Engines, Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1974

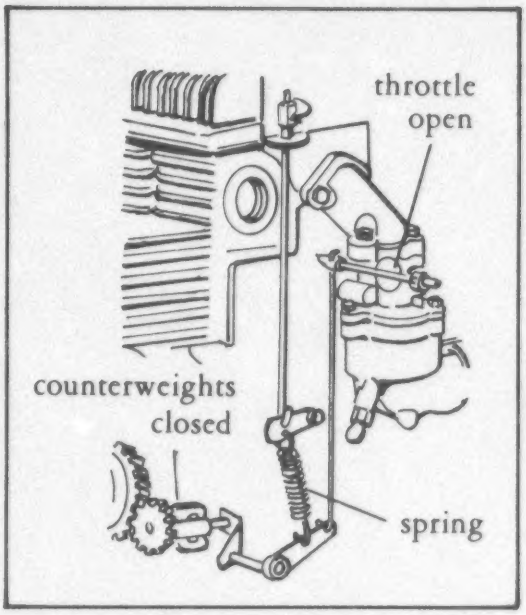
2. "Repair Instruction IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1977

3. "Small Engines Service Manual", Intertec Publishing Corporation, Kansas City, Missouri, 1976

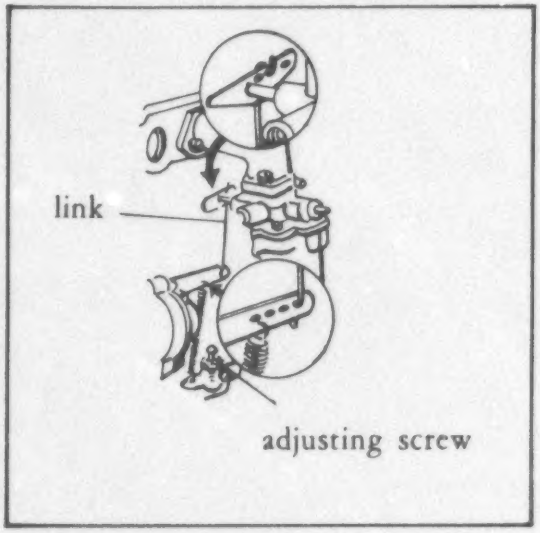
GOVERNORS USED IN SMALL ENGINES



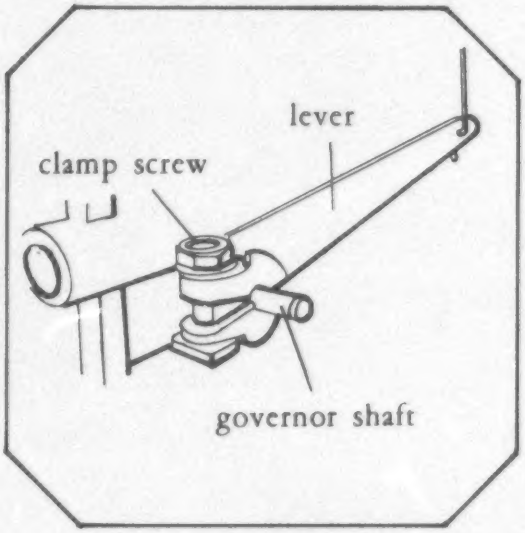
AIR-VANE GOVERNOR



CENTRIFUGAL GOVERNOR

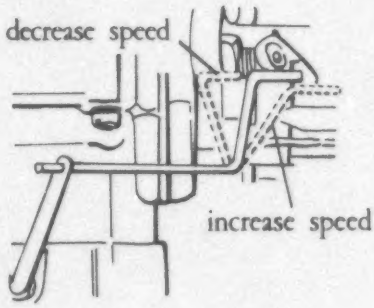


CHANGING LINK

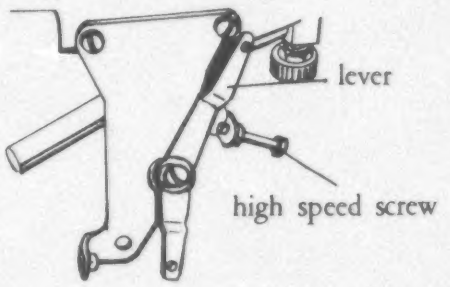


ROTATING LEVER

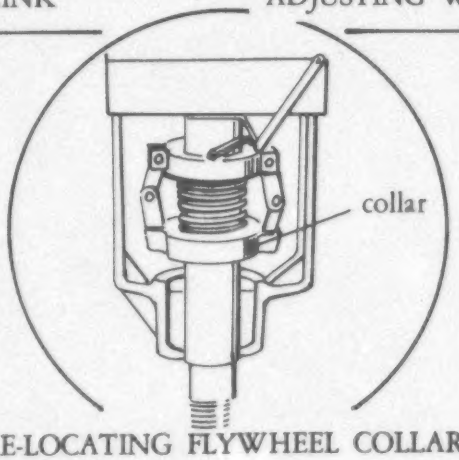
GOVERNORS USED IN SMALL ENGINES



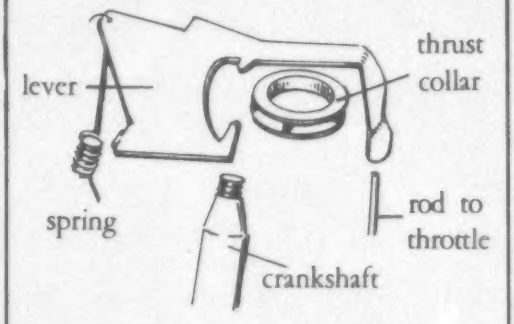
BENDING LINK



ADJUSTING WITH SCREW



RE-LOCATING FLYWHEEL COLLARS



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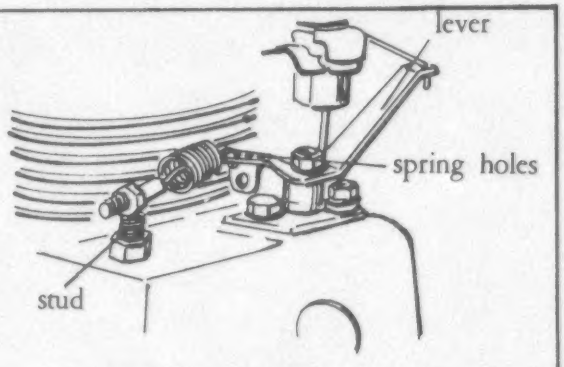


CHANGING LENGTH OF STUD

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A: Small Gasoline Engines

Topic 5: Checking and Adjusting Valves

Suggested Procedures and Activities: If possible use an engine head to show proper and improper valve seating and use several damaged valves during the class discussion.

1. Importance and Functions of Valves

Valves are one of the most important parts of an engine. Without the proper functioning of valves in a four-cycle engine the compression will be low, resulting in the loss of horsepower. They must open and close at the proper time. Each valve opens and closes in about 1/50 of a second when the engine is operating at 3000 rpm. One reason valves must open and close (seal well) properly is that they must withstand pressures up to about 500 pounds per square inch.

Heat is another factor affecting valve functioning and maintenance. The exhaust valve is damaged by heat more than any other part of the engine. Valve heads may be heated to 1200 degrees F. in the combustion chamber. The exhaust valve is difficult to cool due to the hot gases passing over it on their way out of the combustion chamber. The incoming air-fuel mixture cools the intake valve. Two-cycle engine valves (piston has a slide valve, reed valve, and rotary valve) control mainly openings from the carburetor to the crankcase. None of these valves are exposed to the same severe heat condition as found in the four-cycle exhaust valve.

When comparing the differences between two-and four-cycle valve operation, it is noted that a high rpm is used to make up for a smaller displacement in the two-cycle engine. The spark advance is considered greater and horsepower-to-weight ratio is higher for the two-cycle engine. Another difference is that the two-stroke cycle plug fires once each time the crankshaft makes a complete revolution (360 degrees), whereas the four-stroke cycle plug fires once each 720 degrees of operation.

Transparency No. 1

2. Parts of a Valve and Valve Assembly

a. The parts of a four-cycle engine valve include: valve head, margin, face,

and stem.

b. The valve assembly may include the valve seat, valve port, guide, spring, spring washer, keeper or lock, valve lifter or tappet, and camshaft with lobes.

c. The valve spring holds the valve against the seat. It surrounds the valve stem and when compressed provides tension. Pressure is against a washer and keeper at the bottom of the stem. A cam lobe (thick and high place on the camshaft)causes the valve to open the port by raising a tappet that pushes against the valve stem. Some engines are equipped with valve guides that are located about midway the valve in the block and serve as a support for the valve stem.

3. Valve Failures

a. Burned valve face is a common cause of valve failure. It is usually caused by deposits on the face or burning gases escaping by the face due to insufficient tappet clearance. If the face is burned too deep to leave a proper margin after refacing, it should be replaced. The margin should be not less than 1/64 of an inch.

b. A sticking valve is usually caused by the stem binding in the valve stem guide. Excessive heat around the valve stem area causes oil to oxidize and form a varnish on the stem and guide. Also, there may be deposits of carbon, lead, and gum that cause sticking. Valve burning will result if the valve operates partially open. Fuels that are stored for a long period may have a high gum content.

c. A dished valve is actually warped. It has a sunken or cupped head which causes it to seat improperly. There are several reasons why a valve will become dished. The cause may be too high a temperature, too strong a spring, or eroded valve head caused by highly leaded fuel. Dished valves should be replaced.

d. Necked valves are caused from the same conditions affecting dished valves. The stem just below the head is usually eroded away by excessive heat. If the valve neck becomes red hot, the neck elongates when the head strikes the seat.

e. Valve stem keeper wear is not too common but is found on some valves. If the lower part of the valve stem is badly worn by a keeper it should be replaced.

f. Leaking valves are common on many kinds of small engines, and this condition

is caused from burned valves, sticking valves, dished valves, and necked valves. It is also caused from weak or broken springs, warped stem, and burned seats.

Transparency No. 2

4. Removing and Inspecting Valves and Valve Parts

The removal of valves is briefly explained in Unit A, Topic 2. A more detailed explanation of valve and valve parts removal is as follows:

a. After removing the cylinder head from the engine, remove the valve spring cover slip. Place one jaw of the spring compressor on the spring at the tappet end. The other part may be placed on the valve head or the upper end of the spring, depending upon the type compressor used. Force the jaws together and either remove the valve stem pin, stem collars, or retainer washer. A pair of sharp nose pliers can be used to remove the lower stem part. Remove the valve from the engine.

b. Valve springs may be removed or left in place. If the springs are removed mark each according to its original location. Once the spring is removed, it should be checked with a combination square. Measure its height for length and the ends for squareness.

c. Check both the valve guide and stem for wear. Guide measurement is taken with a gauge and micrometer. Measure the valve stem diameter and compare the two measurements. If the clearance of the valve stem to valve guide is .002 to .003, there is adequate space for expansion and lubrication. Drive the old guide out and press a new guide into place if it is necessary to replace the guide.

d. Most valve seats are cut to a 45-degree angle. A few engines may have seats cut to 30 degrees. Check for pitted or cracked faces and warped heads which may cause partial seating.

5. Lapping Valves

Some small engine manufacturers may recommend that valves be reseated by lapping anytime the engine is disassembled or broken down. A compound of coarse silicon carbide and grease (carborundum paste) is used to face valves. The reconditioning procedure is as follows:

a. Apply a thin layer of coarse-grain lapping compound to valve face. Replace the valve in the proper opening; attach lapping tool to top of valve, and rotate

it back and forth applying uniform pressure.

b. Remove or clean away the compound with a solvent and repeat the process using fine grain compound. Clean the valve the second time and apply prussian blue to the face. Insert the valve in the lapped hole and rotate valve with the thumb while applying pressure. A valve properly seated will show bluing to be distributed evenly around the face. Note: The valve must be completely clean before reinstalling it in the engine. A small amount of abrasive compound can damage all moving parts.

Transparency No. 3

6. Adjusting Proper Valve - Tappet Clearance

Recommendations on adjusting the valves may vary with different manufacturers. It may be necessary to install valve springs on some engines before adjusting the valve - tappet clearance, whereas on other engines adjustment is made before installing valve springs. The method used to adjust valve clearance may also vary. A small amount of metal may be removed from valve stem end or the tappets may be adjusted.

On an engine with tappet adjusting screw use the following method:

(1) Use crankcase oil on the valve system (springs, valve, valve guides, and spring retainers). Valves must be clean when making adjustment.

(2) With the valve in the cylinder block turn the crankshaft to top-dead-center on the compression. In this position the valves should be closed and the piston at the top of the cylinder. At this point install the adjusting screw.

(3) Check the operator's manual for valve - tappet clearance and if the valve - tappet clearance is checked with spring in place, compress the proper spring in place and install the retainer locks. Needle nose pliers can be used to install pin-type locks. The retainer lock should be centered on the valve.

(4) Check the valve - tappet clearance by pressing down the valve and measuring the space between the valve and tappet. Adjust the clearance by turning the adjusting screw and tighten jam nuts.

(5) If the engine has no valve tappet adjusting screw, remove the valve and remove the desired amount of metal from the valve end. A

large micrometer can be used to determine the amount of metal removed. Check before grinding the stem and during grinding to determine amount of metal removed. Keep the stem square on the end while grinding. The stem must not be over heated. If the clearance is too short or space too wide, the valve must be refaced and lapped to lower the valve stem.

(6) Reinstall valves in the reverse order of disassembling in the block.

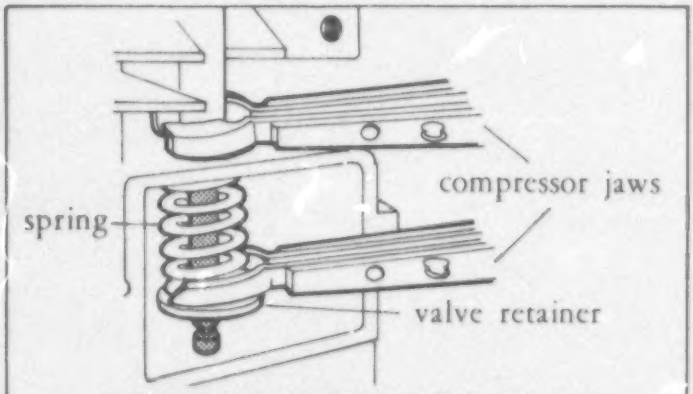
References:

1. Roth, Alfred C., and Ronald J. Baird, Small Engines, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1975

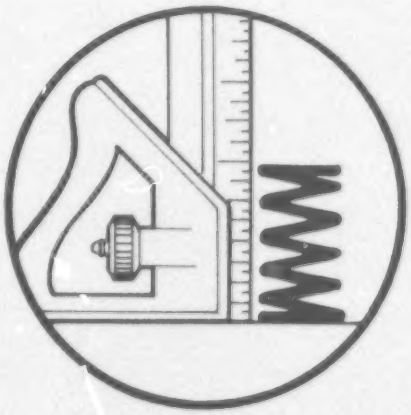
2. "Small Engines, Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1971

3. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1977

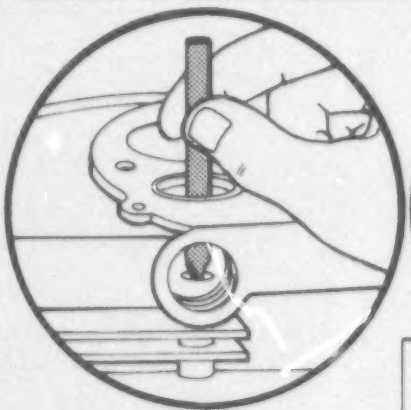
CHECKING VALVES



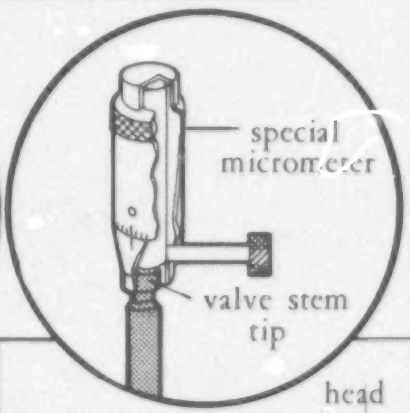
SPRING COMPRESSOR REMOVING SPRING

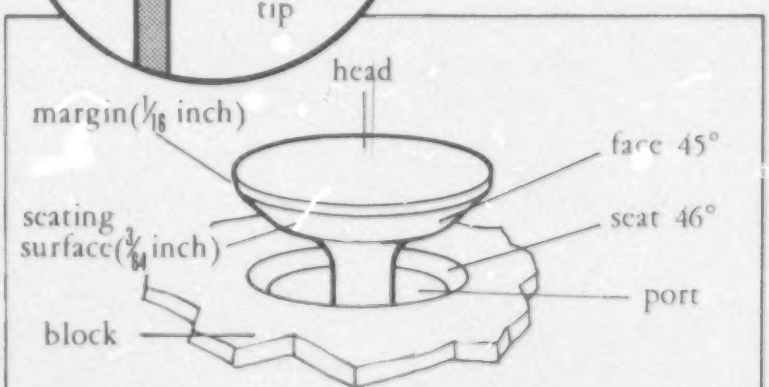


CHECKING SPRING



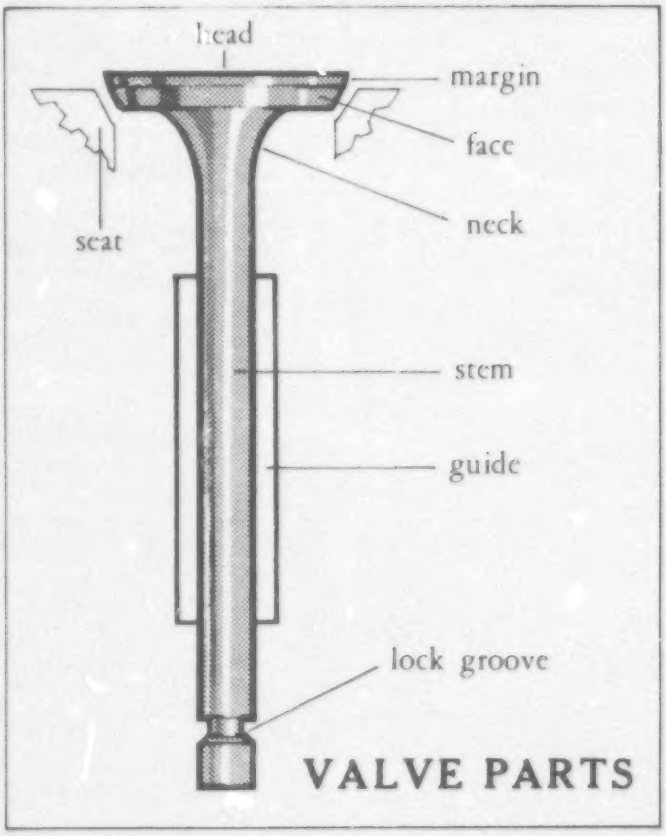
GAUGING GUIDE



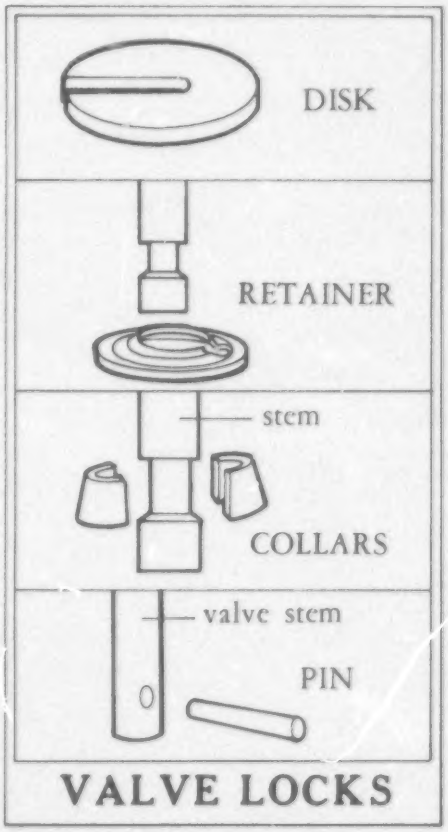


ANGLES & MEASUREMENTS

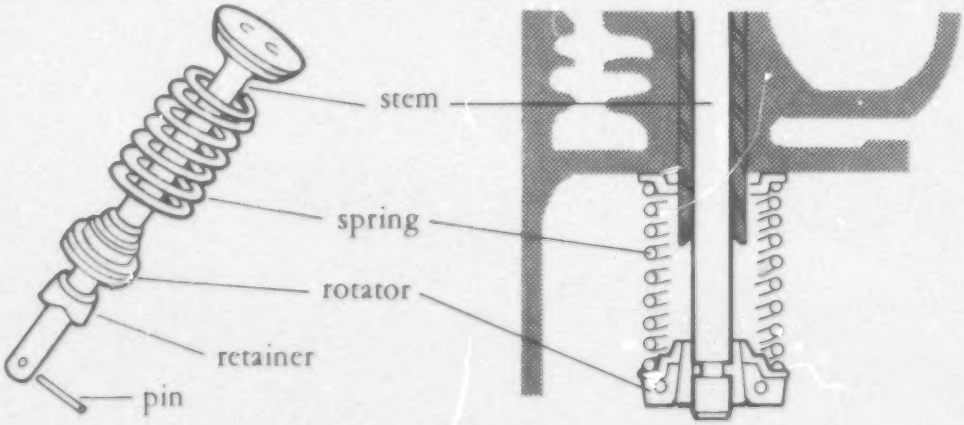
VALVE PARTS



VALVE PARTS

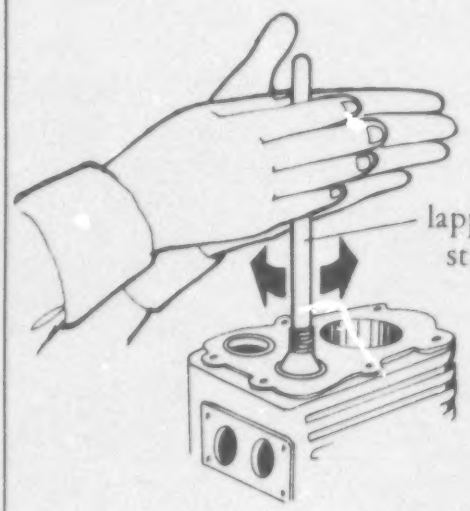


VALVE LOCKS

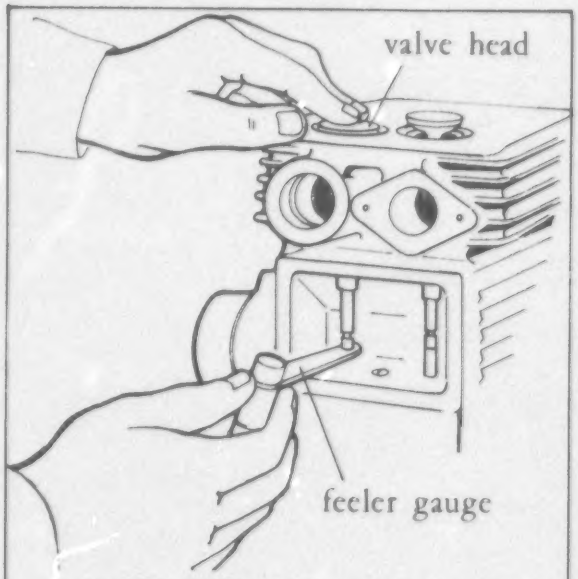


VALVE ASSEMBLY

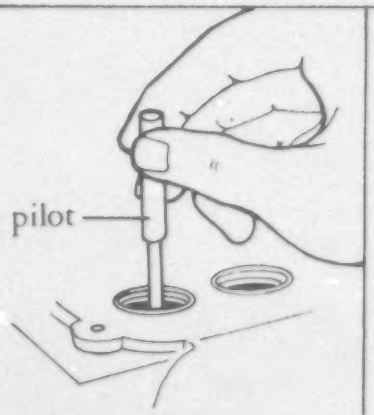
ADJUSTING VALVES



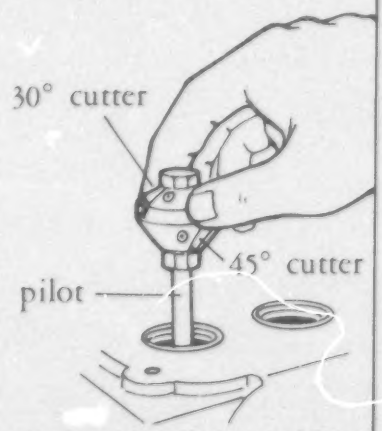
LAPPING VALVE SEAT



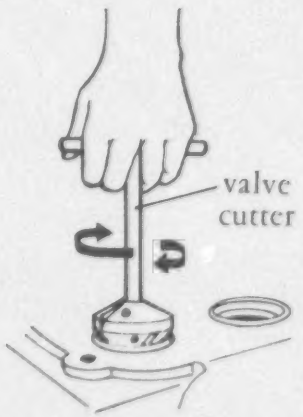
CHECKING VALVE TAPPET CLEARANCE



INSERTING CUTTER PILOT



CONNECTING CUTTER HEAD TO PILOT



CUTTING SEAT

USING VALVE SEAT CUTTER TO REFACE

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A: Small Gasoline Engines

Topic 6: Checking and Adjusting the Electrical System

Suggested Procedures and Activities: Due to most small engines being equipped with magnetos, the use of one as a teaching aid will be helpful during the class discussion.

1. Introduction

The purpose of the ignition system in a small engine is the same as for a large engine. It furnishes a spark at the proper time (just before the piston reaches top-dead-center on the compression stroke) and strong enough to ignite the fuel-air mixture in the combustion chamber. A weak spark may not ignite the fuel, and a spark that is too strong may burn the spark plug electrode.

The three ignition systems found on small engines include the magneto, battery, and solid state.

Transparency No. 1

a. Magneto System - The two most commonly used magnetos are the flywheel and external types. Both types serve the same purposes, to start and operate small engines by properly igniting the fuel. They also produce a very high spark plug voltage (10,000 volts or more). Large engines that require other electrical loads (light, heating, and cooling) are usually equipped with a different type of electrical system.

Flywheel magnets are imbedded in the flywheel and are not visible from outside the engine. They are made of a special alloy called "alnico" (aluminum, nickel, and cobalt). The external system operates in the same manner as the flywheel system. The main differences in the two systems are: they look different and the external system is attached to the outside part of the engine.

The principle of operation is as follows:

The armature pole pieces are separated from the magneto by a small air

gap. The magnetic field is located in the soft iron armature. Lines of force move through the armature coil as the magnet moves past the pole pieces. The coil is made up of a primary winding (several turns of large wire) and secondary winding (many turns of fine wire). Two ends of the primary coil are connected to the breaker points; the other two ends are grounded to the frame of the engine. Current flows through the primary coil as the moving magnets in the flywheel reach the poles with the breaker points closed. When the breaker points open, the magnetic field collapses and lines of force cut through the primary coil for the second time, sending about 100 volts through the coil. The collapsing magnetic field cuts through the secondary coil increasing the current to several thousand volts. A condenser is connected to the primary circuit between the breaker points to prevent excessive arcing between the points and cause the magnetic field to collapse quickly. The most important function of the condenser is to cause a quick collapse of the magnetic field.

Some engines have provision for adjusting the timing whereas others are nonadjustable. Engines that are to be timed have manuals that accompany them giving the degrees or fractions of an inch of piston travel before reaching dead center. The actual timing of the spark is done by having the breaker points open at the proper time. In most engines the breaker points are opened and closed by some type of cam action.

b. The battery ignition system is used on small engines that have starter motors and lights. This system is usually found on garden tractors, riding lawn mowers, and some of the larger stationary small engines. Some small engines may be equipped with both the battery and magneto systems. Usually the battery system has a cam-shaped coil that is mounted some place on the engine. The direct current flows from the battery to a coil, from the coil to a distributor, and then from the distributor to the spark plug(s).

Transparency No. 1

c. The solid state ignition system is similar to the flywheel magneto system in that the magnets are located on the flywheel. Actually, they are the only moving parts of the system. This system is different from the flywheel and external systems in current flow to the spark plug. The current passes through the coil to a diode rectifier where it changes from an alternating to a direct current. This direct current passes through a

capacitor (works similar to a condenser) after remaining stored until the flywheel makes one-half turn, then it flows directly to the spark plug.

2. Cleaning and Adjusting the Spark Plug

a. There are three problems that may cause the malfunctioning of a spark plug. Spark plugs may have cracked or broken insulators, too large electrode gap, and be dirty with carbon, sulphur, and oil build up. A cracked insulator is usually caused by the improper use of a spark plug wrench on removal or replacement of plugs. Carbon builds up inside the base and around the electrode. Ground electrode damage is caused by reverse coil polarity. The metal electrode dishes out at the gap of the center electrode. Continuous sparking wears both electrodes.

Transparency No. 2

b. The method of adjusting the spark plug is as follows:

(1) Remove the metal connector from the plug, loosen it by using a spark plug wrench, blow or remove dirt from the base, and then finish removing the plug.

(2) Replace the spark plug wire and ground the threaded plug area to an unpainted part of the engine. Crank the engine and observe the spark. A multi-line blue-orange spark indicates a good plug. The strength of the spark may be checked by removing the wire and holding the metal connector about one-fourth inch from the cylinder head. A more accurate test can be made by using a spark plug tester.

(3) Clean the plug by using a small-bladed knife to remove carbon and other foreign material from around the center electrode. Clean or file the electrodes by using emery cloth or an electrode file. Wash the plug in a solvent.

(4) Check the gap with a wire gauge and bend the metal electrode properly. If the gap is too wide, the ignition system may not produce enough voltage for a spark to jump the gap. A flat feeler gauge may be used on a new plug, but a wire gauge is recommended where the ground electrode may be pitted or dished.

3. Checking and Adjusting Breaker Points

a. The problems encountered with breaker points are pitting, being worn, oily, or dirty, and having too wide a gap. Points that are badly pitted or worn must be replaced. Oily and dirty points can usually be cleaned by using carbon tetrachloride and a lint free cloth or card. Points that have too wide a gap can cause kick-back when starting the engine due to the spark timing being advanced. A retarded spark timing, caused by the points being set too close, will reduce engine power.

b. In order to gain access to the breaker point assembly on flywheel magnetos, it is necessary to remove the flywheel and in some cases the dust cover. On external type engines, it is necessary to remove the external breaker box cover to gain access to the magneto.

Transparency No. 3

c. Steps to follow in checking and adjusting the points are:

(1) Adjust for alignment of points before attempting to set them.

(2) Turn the crankshaft until the points are spread apart as far as possible.

(3) Remove the spark-advance mechanism if one is located on the engine.

(4) Turn the eccentric screw on the fixed arm (some engines) to provide the desired gap. The lock nut may be tightened without moving the screw. Use a feeler gauge to determine the proper gap with the back lever resting on the high point (lobe) of cam. Some small engines can be adjusted by the use of a timing pin and timing light. This procedure is accomplished by connecting one timing light lead to a ground on the engine and the other to the movable arm. Disconnect coil to breaker point lead and insert timing pin in the hole at bottom of the engine. Rotate the flywheel until the pin slips into the timing hole on the flywheel. Lock the eccentric screw into position while turning at the point the light goes out. It is usually advisable to replace breaker points instead of trying to recondition them for extended use.

(5) Remove the condenser and have it tested on a condenser tester. It protects the breaker points; therefore, it is recommended that a new condenser be installed with new breaker points.

(6) Not all engines have provisions for adjusting the stator-plate (armature) air gap. This may referred to as flywheel - to - lamination gap. It is a measurement of clearance between the rotating magnet and laminated iron arms or legs. This method is also used to check the solid state ignition system (air gap measurement between the flywheel and the solid state ignition unit). If the gap is greater than 0.012 inch, the magnetic force lines will be weak in the lamination causing the primary current not to be induced. If the clearance is less than 0.008, the legs (arms) may interfere with the rotation of the flywheel. Use a feeler gauge to check the gap between the flywheel and the two legs. Two other types of stator-plates (armatures) are: stator-plate under the flywheel and stator-plate under the flywheel with magnets mounted in a rotor that turns within the stator-plate.

Transparency No. 3

d. A method used to check the air gap clearance is as follows:

(1) Place a regular postal card between the stator-plate and flywheel. The card thickness should range from .007 to .012 inches.

(2) Rotate the flywheel by hand and check clearance between the card and stator-plate (armature). The rotating magnets should be in line with the armature in order to make air gap adjustment. The stator-plate must be loose for the magnets to pull it against the card on the flywheel.

(3) Tighten the stator-plate and remove the card. A feeler gauge may be used to check the air gap or recheck the gap after a postal card is used. The gauge should be used in areas away from the magnets.

(4) If the stator-plate is located under the flywheel, the flywheel must be removed, a piece of electrician's tape placed on the inner rim, and the wheel turned about a dozen times before removing and checking the tape for scuffing. Scratched or marred tape means the setting is too close. Unmarred tape requires the addition of a second piece using the same procedure, and if the tape is not marred (2 thicknesses) the gap is too wide and the plate must be reset.

(5) When checking the air gap with the magnet on a separate rotor and under the flywheel, check the gap in four places with a 1/2 inch wide feeler gauge. Turn the crankshaft by hand with the spark plug

removed. If the air gap clearance is too small (below .004 inch) or too large, check the bearings and crankshaft for wear. The stator-plate cannot be moved.

References:

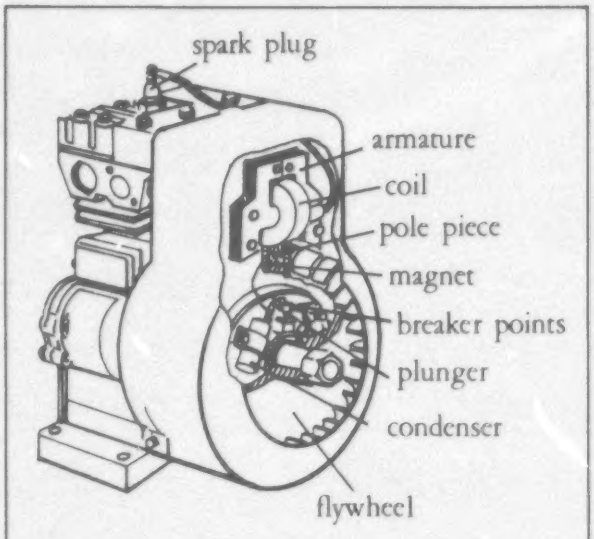
1. "Small Engines, Care and Operation, Volume I", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

2. "Small Engines, Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1974

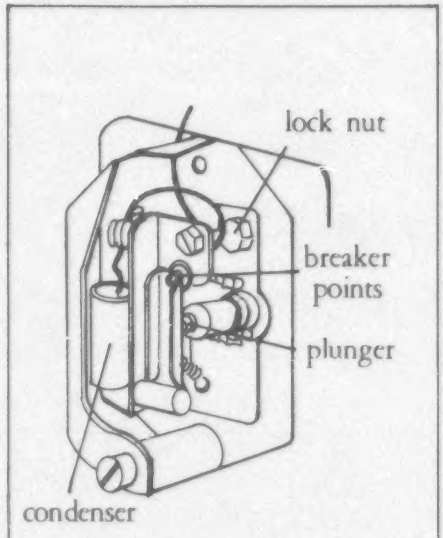
3. "The Two-Cycle Engine", University of Illinois, Urbana, Illinois, 1970

4. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1977

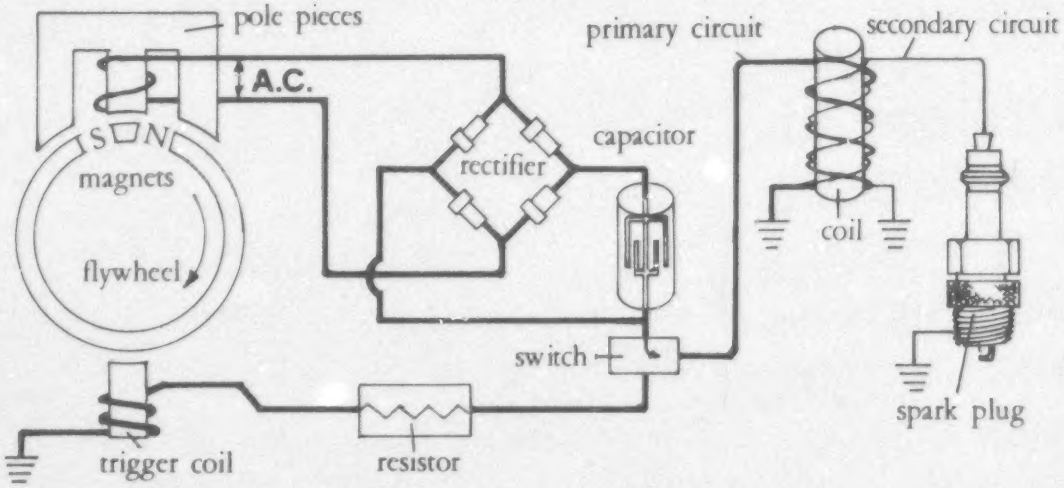
ELECTRICAL SYSTEM
MAGNETO AND SOLID STATE



INTERNAL BREAKER



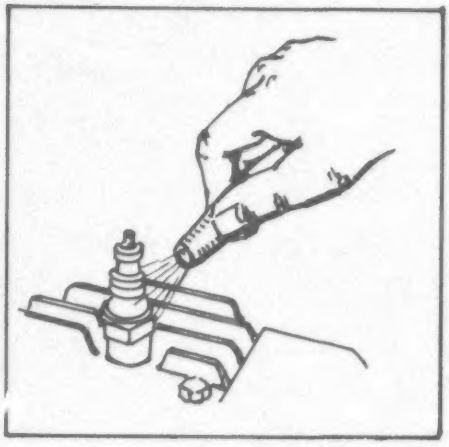
EXTERNAL BREAKER



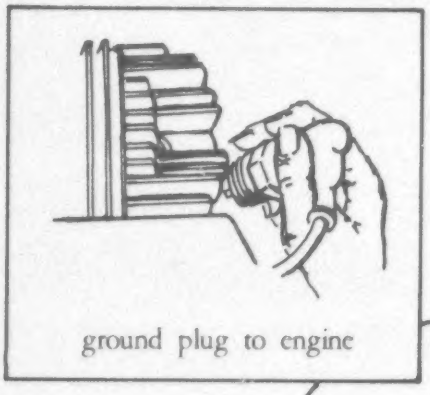
SOLID STATE IGNITION SYSTEM - FLYWHEEL MAGNETO

ELECTRICAL SYSTEM
SPARK PLUG MAINTENANCE

removing metal connector

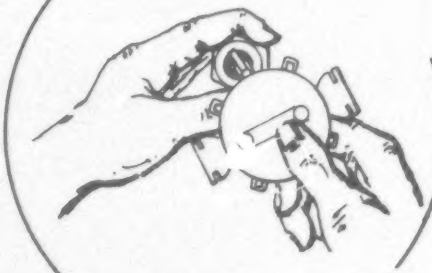


cleaning plug area



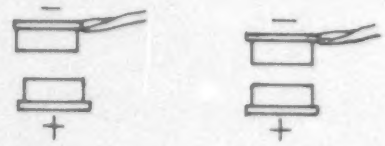
ground plug to engine

cleaning plug



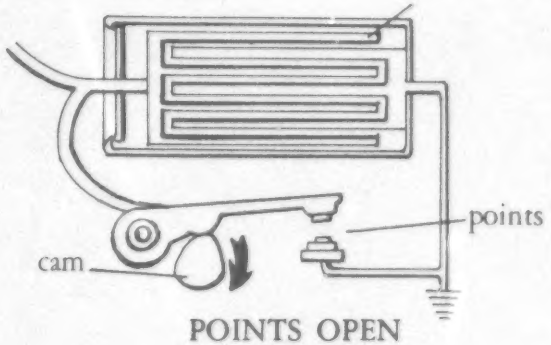
using wire gauge to set gap

ELECTRICAL SYSTEM ADJUSTMENTS



POINTS OUT OF LINE

POINTS IN LINE



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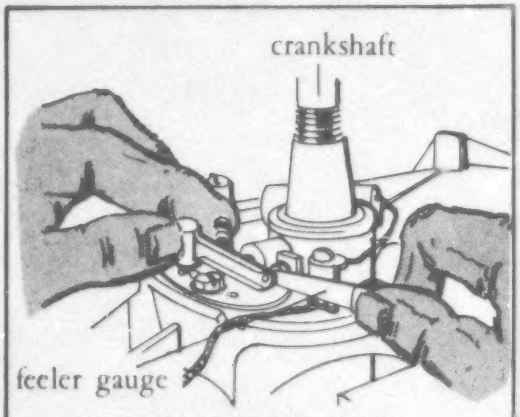
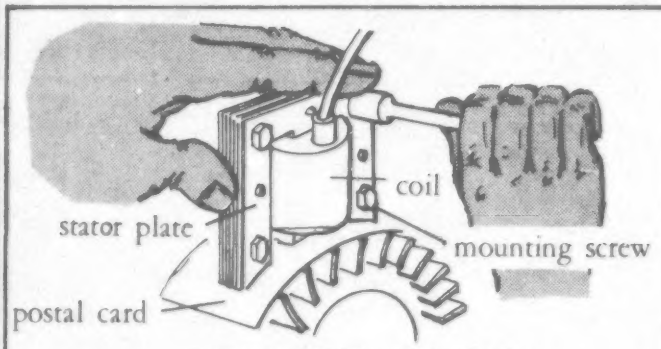
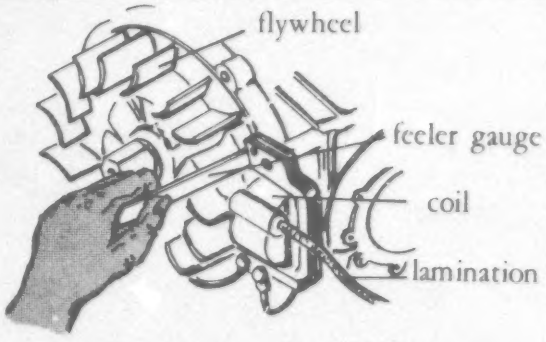


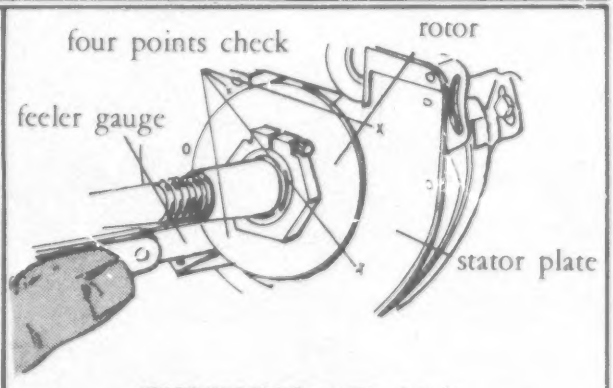
ADJUSTING GAP



ADJUSTING AIR GAP



CHECKING AIR GAP BETWEEN LAMINATION & FLYWHEEL



CHECKING AIR GAP ON MAGNA-MATIC SYSTEM

76A

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A : Small Gasoline Engines

Topic 7: Inspecting and Repairing the Cylinder and Piston

Suggested Procedures and Activities: An engine block and piston assembly can be used as teaching aids during the class discussion.

1. General Information

Some of the main causes of an engine having poor compression are due to a worn cylinder, worn piston rings, and worn pistons. There are two types of cylinder units found in small engines. The most common type is the one-piece integral cylinder block plus the crankcase. The less common type is the separate cylinder block bolted to the crankcase.

2. Inspecting the Cylinder and Making Adjustments

Transparency No. 1

a. Check for a ridge ring at the top of the cylinder. The thickness of the ridge may be checked by using a micrometer. Remove the ridge before the piston is removed. Cut the ridge even with the piston wall by using a ridge removing tool. It will be necessary to rebore the cylinder if the wall is cut too deep. If there is no ring, the piston can be removed easily through the cylinder top.

b. Cracks or heavy scar marks will normally require the reboring of a cylinder. If reboring is necessary, take the block to a machine shop that has boring equipment. Heavy scar marks can cause loss of compression and oil. If the marks are too deep for oversizing, replace the block. A cracked cylinder should be replaced. A cracked cylinder will leak oil and lose compression. Some conditions causing scarring are: overheating, lack of lubrication, and incorrect piston clearance.

c. Broken fins may cause hot spots on the engine. In that they cannot be repaired, replacement may be necessary. Stripped bolt holes can be repaired with thread inserts; therefore, block replacement is usually not necessary.

Transparency No. 1

d. Carefully measure each cylinder diameter with an inside micrometer. Compare the original factory cylinder diameter with the current measurements to determine whether or not the cylinder has been rebored and the amount of reboring which was done. The diameter at both top and bottom of ring travel can be determined by using a telescoping gauge. Taper can also be determined by measuring ring end gap at both top and bottom of the cylinder. The difference between the two measurements is divided by π which is a difference in circumference.

Transparencies Nos. 1 and 2

e. Check the cylinder for out-of-round by using a telescoping gauge. The cylinder is checked at right angles to the crankshaft and parallel measurements to the crankshaft. Compare the parallel measurements with the right angle measurements at the top and bottom ring travel zones in the cylinder bore (parallel top with right angle top). If excessive out-of-roundness (.005 inch or more) or taper is present, the cylinders must be rebored. Minor taper and out-of-roundness may require only deglazing. The two major types of deglazers are the ridge and flexible. Both types leave a cross pattern on the cylinder wall that provide cavities for holding oil during piston break-in. After a cylinder is rebored (first time .010 of an inch and second time .020) it is deglazed or honed. This repair job is accomplished by using an abrasive tool mounted in the electric drill. The honing tool is moved up and down in the cylinder. It should remain far enough in the cylinder so that the guides and stone can be kept straight and steady. Adjust the stone against the cylinder walls loose enough that it can be turned by hand. Usually, it is advisable to cut the bottom of the cylinder first. Remove the stone and measure the size of the cylinder from time to time during the honing process. It is advisable to change to a fine stone when the cylinder is within .002 of the desired bore. After a cylinder has been deglazed it is very important that it be perfectly cleaned. However, it is not advisable to use gasoline, kerosene, or commercial cleaners to clean cylinders. These solvents will not remove abrasions from the walls. Use soap and water followed with 10 weight oil and several clean rags to clean reconditioned cylinders.

f. There are two types of cylinders that cannot be rebored. They are: chrome plated aluminum and cylinders formed by a flanged sleeve. Solid cast iron and cast-in-sleeve types can be rebored.

Many shops are not equipped with reboring equipment; therefore, it may be necessary to diagnose to rebore condition and have the work performed by a shop that is equipped for such jobs.

g. When removing cylinder sleeves a special sleeve puller is required to remove sleeves or liners. Most sleeves can be removed at room temperature unless the liners are completely frozen to the cylinder walls. A good penetrating oil or solvent may be used to advantage. In some cases heat is used to help free the liner before it is pulled. To properly install a sleeve, the counterbore area should be clean and the liner must fit perfectly on the bore to prevent distortion; therefore, it is necessary to clean all carbon deposits from under the flange of the liner and mating bore. In some cases it may be necessary to shim the liner to bring it to a proper height or to the manufacturer's specification.

Transparencies Nos. 2 and 3

3. Pistons and Piston Service

The main jobs of pistons are to take the force of combustion and transmit it to the crankshaft. They also carry the piston rings that seal and clean the cylinders.

a. Pistons are made up of the following parts: head, skirt, ring grooves, piston pin boss, and lands. The purposes of the parts are:

(1) The piston head receives the pressure exerted by the combustion gases. The top of the head may be concave, flat, or irregular.

(2) The skirt is located below the ring grooves. It helps keep the piston in alignment. It is elliptical in shape and tapered.

(3) The ring grooves are cut around the piston to hold the rings. The ring grooves are different in sizes. Usually the lower and wider groove has openings that permit the oil to flow back from the oil control ring.

(4) The piston lands are the metal ridges between the ring grooves that support or hold the rings in place.

b. Cleaning pistons and checking ring grooves are very important steps in piston repair. Remove the rings from the piston by using a ring removing tool and place the piston in a carbon removing solution. Rinse the piston and let it dry. Mount the piston in a vise by clamping the connecting rod just below the skirt. Examine and service grooves in the following ways:

(1) Clean carbon from the grooves with a ring groove cleaning tool or

broken piston ring. Examine the grooves for side wear, dents, and burns. Check the compression groove for wear because most of the ring wear occurs at this ring location.

(2) Check groove widths with a new ring and feeler gauge. If side clearance is more than .008 inch, excessive wear is present. Clearance may vary from .002 to .007 inches. The manufacturer's specifications will give the proper measurements. Grooves do not wear evenly, so they should be checked in several places. Special gauges are available for checking grooves.

(3) If the ring groove needs to be reconditioned, cut the groove wider and install a steel spacer above the new piston ring. There are both manual and power driven tools used to recondition grooves. If the top ring groove is not repaired, it may cause the piston to be damaged and fail, which in turn will cause other parts of the engine to be damaged and fail.

(4) Check the piston for cracks, scuffing, scarring, and burning.

(a) Check all pistons for signs of cracking. Cracks may be found around pin bosses and piston skirts. Do not use a piston that shows any signs of cracking.
(b) Scuffing and scarring may be caused by the lack of proper lubrication, improper warm up, clogged cooling system, preignition, and overloading. Reject a badly scarred piston.
(c) Preignition usually is the cause of burning. This condition may be corrected by proper fuel mixtures, proper timing, and tightening the spark plugs. Discard any piston that has a badly burned top. Usually if a piston is severely burned a hole will appear in the top.

(5) Check and correct the following physical condition or conditions that cause damage to pistons: connecting rod out of alignment, too much crankshaft play, taper on the crankshaft journal, cylinder bore out of alignment, and faulty piston pins.

c. To resize and fit the piston use the following procedure:

The piston may be placed in the cylinder bore where it will be used. One method of checking the piston for size is to invert it and place it in the bore. A feeler gauge or spring scale may be used to check the clearance (.005 to .010 inch in some engines) between the piston and the bore wall. It may be necessary to resize or expand the piston to fit the cylinder. If a new piston

is too large, it is shaved until the size is correct. The piston may be knurled with a wire brush or knurling tool to increase the size. The thrust areas of the skirt are made larger by knurling. Spring skirt expanders are also used to enlarge the skirt size. The inside measurement of the bore and the outside measurement of the piston is another way to check clearance.

d. Check the piston pin to be sure that it fits tightly enough to prevent pin knock, yet be loose enough to be sufficiently oiled. The pin hole must be perfectly straight, smooth, and free of taper. Check the pin fit by clamping the connecting rod in a vise and rocking the piston back and forth. If the hole is tapered or the pin does not fit properly, the movement should identify the need for adjustment. The piston-pin bore can be checked with an inside micrometer and gauge. An outside micrometer is used to check the pin.

Transparency No. 4

e. The piston pin is installed by first installing a lock ring in one pin opening on the piston. If needle bearings are used, they can be held in place by coating them with heavy grease. Oil the rod bearing and piston bore. Place the rod bearing in line with the pin holes in the piston and insert the pin. If the pin is a little too large, heat the piston to expand the holes and place the pin in dry ice before trying to install it. Install the second pin lock ring after installing the pin. Types of pins are: fixed, semi-floating, and floating.

Transparency No. 4

4. Piston Rings

a. There are two types of piston rings, compression and oil control. The compression rings exert pressure on the cylinder wall to compress the fuel mixture into a small space and prevent gases from passing by the piston during the compression and power stroke. The oil control ring is usually located below the compression and power stroke. The ring is usually perforated or slotted to allow oil to be spread over the cylinder wall and wipe excess oil from the wall.

Various shapes of piston rings are used in tractors. Some of the more common shapes are: rectangular, barrel-face, inside bevel, taperface, and keystone.

The most common ring joints are step, angle, and straight. The straight joint is the most widely used of the three.

b. When installing it is advisable to follow the installation directions that are furnished with each set of rings. If the cylinders have been rebored, a rebore set of rings should be used. Otherwise, an oil control set is adequate. The steps for installing rings are:

(1) Place the ring inside the cylinder where it is to be used. Push it to the bottom of the ring travel with an inverted piston. Measure the ring gap while it is in this position. Allow .003 to .004 inch gap per inch of cylinder diameter. Use a feeler gauge to take the measurement. The gap allows for heat expansion and facilitates placing the ring on the piston.

(2) The proper ring side clearance is important; therefore, place the ring in the ring groove and roll it around the piston. If the ring does not move freely around the groove, it may bind on expansion, thus keeping it from sealing, which will cause a blow-by. Check the ring clearance with a feeler gauge with part of the ring in the groove.

(3) Place the bottom oil ring on the piston and continue to work up until all rings are installed. If a multiple type oil ring (expander and rails) is used, all gaps should be at least one inch apart. Use a ring expander to place the rings in the proper groove turned the right way.

Transparency No. 5

5. Connecting Rods

The connecting rod of an engine must be light and strong. It transmits the thrust against the piston to the crankshaft. The rod parts are the cap, head, shank, and eye. The cap, head, and eye contain bearings or inserts. The head is connected to the crankshaft journal and the eye to a piston pin.

a. It is important that the engine connecting rods be checked because it is customary to reuse the rods in an engine after overhauling it; therefore, they should be thoroughly examined and adjustments made before the engine is assembled. The rods are checked in the following manner:

(1) Check the rods for twist and bend. Twisting causes the center-lines of the upper and lower bores to be out of alignment. A bend will cause the upper bore to not be parallel to the lower bore.

It is recommended that a twisted or bent rod be replaced with a new one.

(2) Check the crankshaft bore for roundness on some engines. Use a telecoping gauge and a micrometer to take measurements with the cap torqued. Out-of-roundness should not exceed more than .001 inch. Inside measurements should be taken in several locations. To correct out-of roundness, a special grinder is used to remove metal from both the upper and lower parts of the bore. After the metal is removed, the cap is replaced and torqued. Remove rough stock by honing and recheck for roundness and size.

Transparency No. 5

6. Installing Rod and Piston Assembly

The steps to follow in assembling the connecting rod and piston are:

a. After checking the entire rod and piston assembly, lubricate the piston, piston pin, rings, and other parts. Clean the bore with a cloth. Do not use a solvent.

b. Place a piston ring compressor over the rings and tighten. With the piston head turned upside down, push the compressor on the piston evenly and finish tightening. After the compressor is drawn up tight, looser it slightly. Place the connecting rod and piston with rings compressed into the cylinder in the proper position. Push the piston down into the cylinder. This step removes the ring compressor.

c. Remove the rod cap and wipe excess oil from the crankshaft and insert. Place the connecting rod over the crankshaft crankpin, and replace the rod cap and screw locks after putting a strip of plastigage across the insert. Tighten the rod cap with a torque wrench using recommendations from the service manual. Remove the cap and measure the plastigage at its widest point using the plastigage scale. The proper clearance is indicated by the number corresponding to the width of the plastigage. The plastigage is removed and the cap torqued. The proper side clearance is also important; therefore, the manufacturer's specifications should be followed when taking this measurement.

It is a good practice to record measurements when disassembling and assembling an engine.

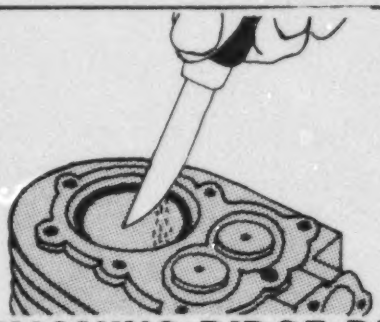
References:

1. Roth, C. Alfred and Ronald J. Baird, Small Engines Fundamentals, Service, Troubleshooting and Repairs, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1975

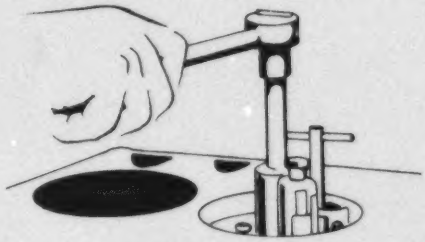
2. "Small Engines Maintenance and Repair, Volume IV", American Association for Vocational Instructional Materials, Athens, Georgia, 1974

3. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1977

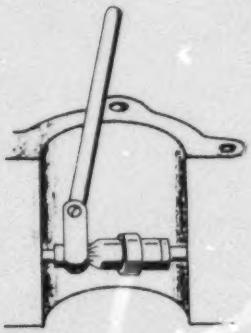
REMOVING RIDGE & CHECKING CYLINDER



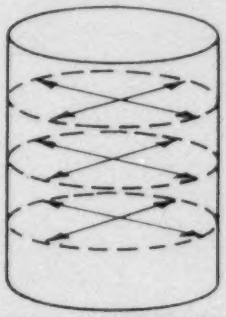
REMOVING RIDGE RING



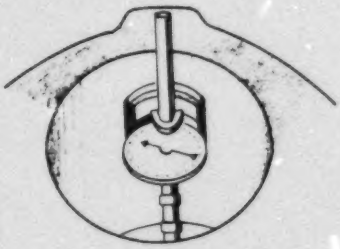
REMOVING RIDGE



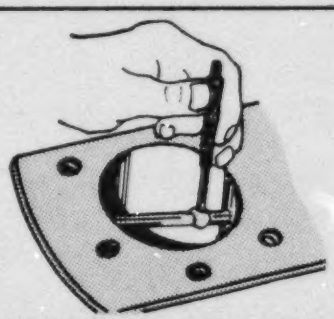
INSIDE MICROMETER



SIX MEASUREMENTS IN CYLINDER

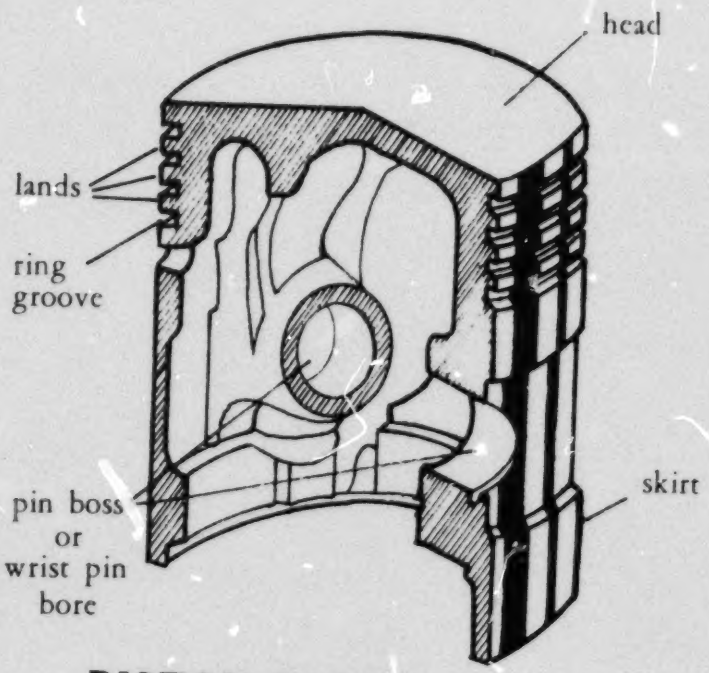


TAPER GAGE



MEASURING CYLINDER SIZE OUT OF ROUND

PISTON PARTS & DEGLAZING CYLINDER

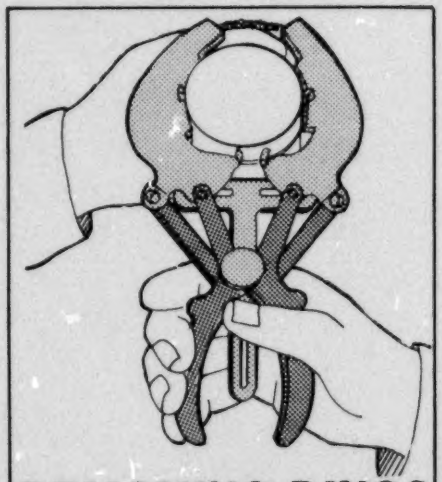


PISTON PARTS

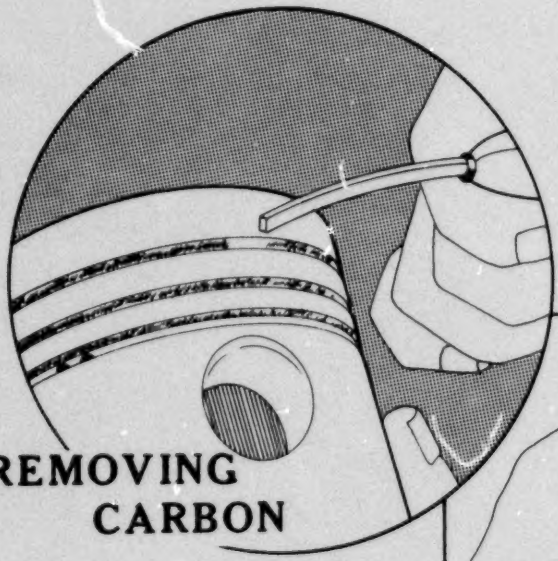
HONING CYLINDER

DEGLAZING PISTON SLEEVE

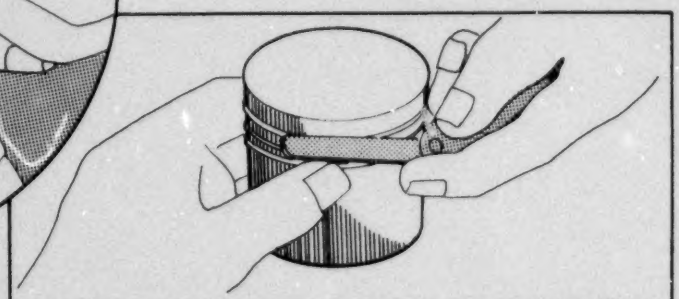
CHECKING PISTON



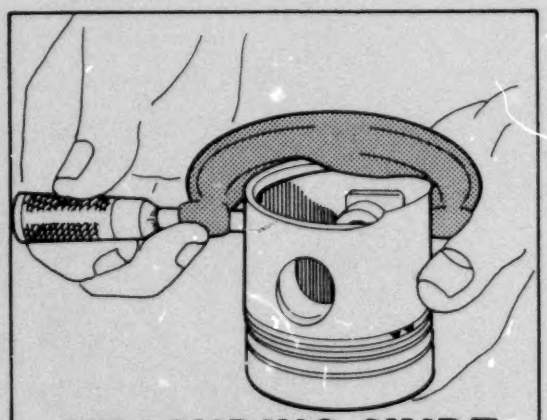
REMOVING RINGS



REMOVING CARBON



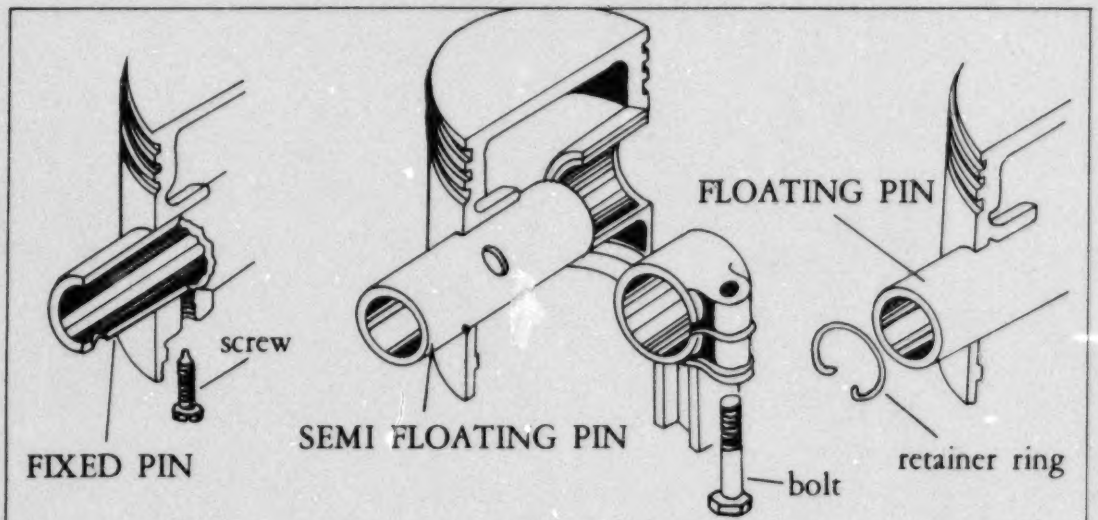
CHECKING GROOVE WIDTH



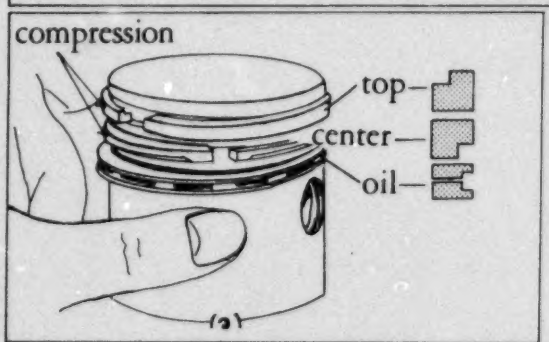
MEASURING SKIRT

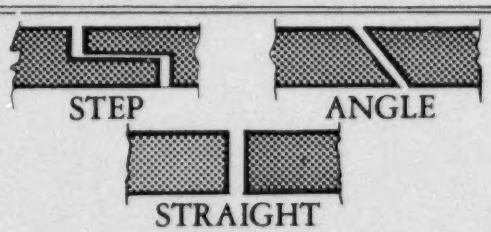
MEASURING TOP

PISTON RINGS AND PINS

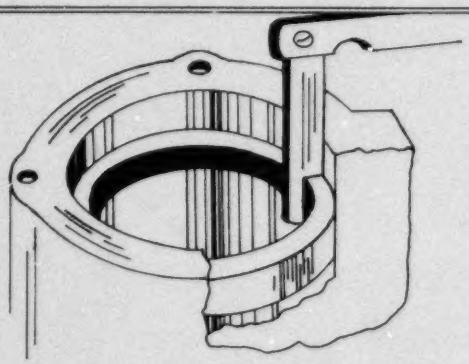


TYPES OF PINS AND PIN FASTENERS

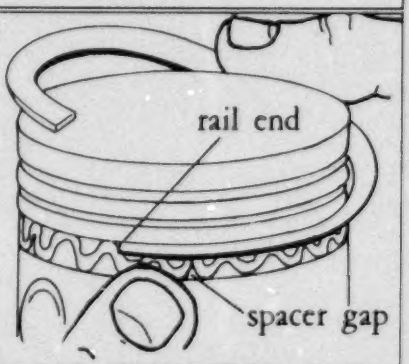




JOINTS

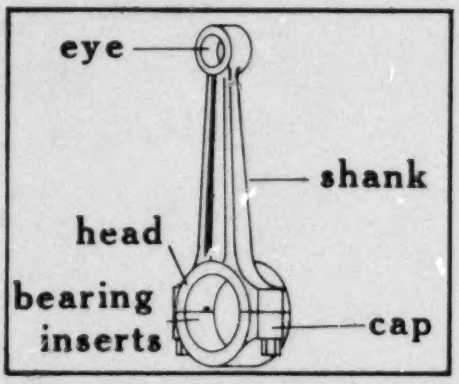


MEASURING NEW RING GAP

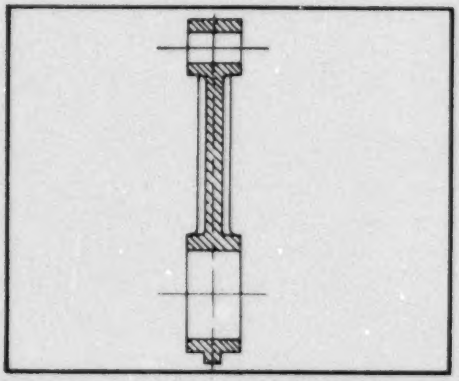


INSTALLING EXPANDER AND OIL RING

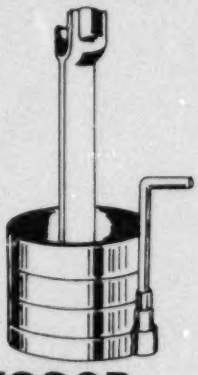
CONNECTING ROD & PISTON INSTALLATION



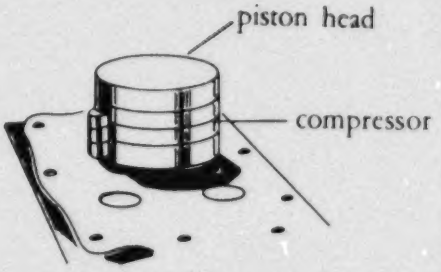
CONNECTING ROD PARTS



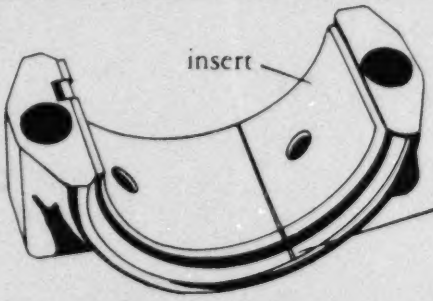
STRAIGHT CONNECTING ROD



PISTON IN RING COMPRESSOR



PISTON FORCED INTO CYLINDER



ROD CAP

PLASTIGAGE

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit A: Small Gasoline Engines

Topic 8: Inspecting and Servicing Engine Lubrication System

Suggested Procedures and Activities: Oil and grease samples in glass containers can be used as teaching aids during the class discussion.

1. Purpose of Lubrication

Lubricating oil functions the same in small engines as in large engines. It reduces both friction and wear in the engine. Naturally, when friction is reduced, wear is reduced. Other important functions of oil are:

a. Oil is a good conductor of heat. It dissipates heat by transferring it to metal parts that are cooled by air and water. As the oil leaves the crankcase it carries heat out.

b. Oil forms a film between the piston rings and cylinder walls, locking power in the engine. If the combustion gases were allowed to "blow-by" the piston into the crankcase, the pressure in the combustion chamber would be reduced, thus reducing the power.

c. Oil washes small particles of metal from engine parts. The metal is filtered out or settles in the crankcase. Oil also picks up dirt particles which are either trapped in a filter or the crankcase.

d. Oil serves as a shock absorber, because it is forced from bearing surfaces slowly. The sudden shock of combustion is cushioned by oil as it is transferred to the bearings on the power stroke. This is another reason oil is used to separate parts.

e. Oil is a protector of steel in another way, as it forms a film to keep air and moisture away from the metal. Metal will oxidize (rust) or even corrode if it is not protected.

Transparency No. 1

2. Lubrication in Two-Cycle and Four-Cycle Engines

a. Oil is mixed with gasoline, forming the fuel-lubricant mixture that is used in the two-cycle engine. As the piston moves downward toward the crankshaft,

oil is condensed on the bearing surfaces. This movement pressurizes oil in the crankcase. On the upward movement, oil condenses from the fuel mixture and lubricates the cylinder walls, piston, and rings. The remainder of the oil is burned in the combustion chamber.

b. In a four-cycle engine, the oil is located in the sump, where it is moved by one of four common methods to bearings and other moving parts. These methods are as follows:

(1) In the pump and dipper method, oil is pumped and sprayed on the dipper. The dipper splashes the oil to parts inside the engine. In this type of lubricating system, the oil may be pumped into a second sump and then splashed to parts of the engine by a dipper mounted on the rod bearing cap.

(2) Another type is the slinger method, where the oil is picked up by a rotating slinger driven by the cam gear and splashed about to engine parts.

(3) The dipper and sump method is very common in small engines. A dipper is mounted on the rod cap, and it also splashes oil to various parts of the engine.

(4) An oil pump forces oil through drilled passageways to the bearings and other parts. The oil is picked up from the oil sump by the pump. Most oil pumps need little servicing. They are located inside the oil sump.

3. Selecting Engine Oil

Whereas two-cycle engines use two-cycle special oil, lubricating oils used in four-cycle engines are the same oils used in automobiles. Oils are selected according to their API (American Petroleum Institute) service classification and the type of oil by SAE grade (Society of Automotive Engineers), which is the viscosity grade or oil thickness.

a. The API Classification for small engine oil is SD (Service Deluxe) which was formerly MS oil. This type of oil protects the engine against wear, corrosion, rust, and deposits. They also protect the engine against high and low temperatures. SC oils are also used in small engines.

b. SAE Classification identifies the grade of oil by a number. The highest number used is the thickest oil. The most common oils used are SAE 10W,

SAE 20, and SAE 30. The "W" means that the oil is also recommended for subfreeezing temperature. Multigrade oils are also used in small engines. The most common oil for this area is SAE 10W-30. This oil is referred to as an all-season oil.

c. Most oils contain additives. Pour-point depressants, oxidation and bearing inhibitors, foam inhibitors, rust inhibitors, and detergents are the most commonly used additives. Oils containing detergents are recommended for small engines. Detergents help keep the engine clean by preventing the formation of sludge and varnish.

4. Importance of Lubricating the Small Engine at Frequent Intervals

a. Oil is changed frequently to remove dirt, sludge, and metal particles, because most small engines operate without an oil filter.

b. The oil in a small engine usually is very hot when the engine is operating, due to its being air-cooled. The oil oxidizes and breaks down more readily than in a water-cooled engine.

c. Most small engines operate without any type of oil pressure gauge to indicate low pressure.

d. Small engines are usually operated on or near the ground, and this makes the engine more accessible to dirt and dust.

e. Lightweight engines usually vibrate more than heavy engines, and this puts more strain on the bearings. They also use a small amount of oil.

f. Due to most small engines operating at maximum power output, oil is forced out from between bearing surfaces.

g. Small engines usually operate for short intervals; therefore, they are started often, causing more wear than running properly long periods of time.

Transparency No. 1

5. Checking and Changing the Crankcase Oil in A Four-Cycle Engine

a. Check the oil level each time the engine is refueled or every two to four hours of operation. A procedure used in checking the oil is as follows:

(1) Remove the filler plug or cap after cleaning dust, dirt, and grease away from the area.

(2) With the engine level, remove the dipstick, if the engine has one, and wipe clean with a rag. Then re-insert dipstick for checking the oil level. Add oil as needed but never above the "full" mark. Oil should be added if the oil ring is below the "add" mark.

(3) Check the oil level on an engine that has no stick by observing the oil level through the filler hole. Some engines may have a marking or slot that will indicate the level when the crankcase is full. Other engines that have no full marks are considered full if the oil level comes to the top of the filler hole.

b. Oil is usually changed in a new engine after about five hours of operation. After this point the oil is changed about every twenty-five hours of operation except when the engine is operated under dusty or abnormal conditions. A procedure for changing the oil is as follows:

(1) Operate the engine until the oil becomes heated. Hot oil will pour more freely, and the contaminants will be dispersed in the oil that is drained out.

(2) Disconnect the spark plug before attempting to remove the drain plug. If an engine has no drain plug, the old oil is removed through the filler neck. It is a common practice to remove dirt and grease from the plug area before removing it.

(3) Allow the engine to drain long enough so that oil from various parts will drain into the crankcase.

(4) Tilt engine if the drain plug is on the side or when draining from the filler neck.

(5) After refilling the crankcase with new oil, replace drain plug and spark plug wire and operate the engine for a few minutes. Stop the engine and check the oil level. Add oil if necessary to the full line.

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2. Stephenson, George E., Small Gas Engines, Delmar Publishers, Albany,

New York, 1973

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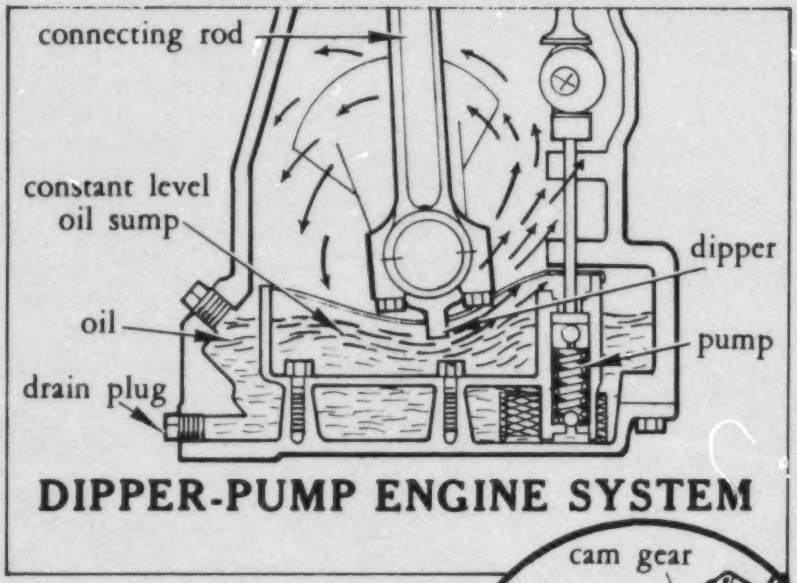
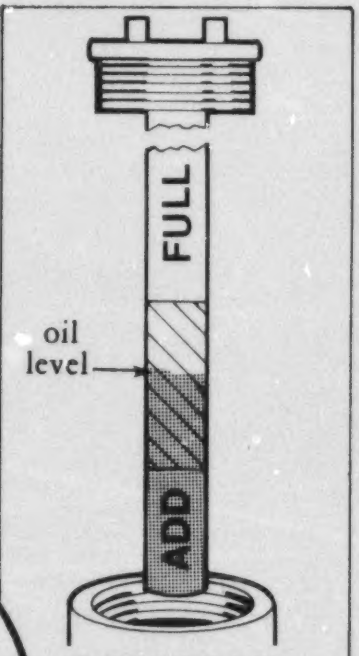
4. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1977

LUBRICATION SYSTEMS



DIPPER-PUMP ENGINE SYSTEM



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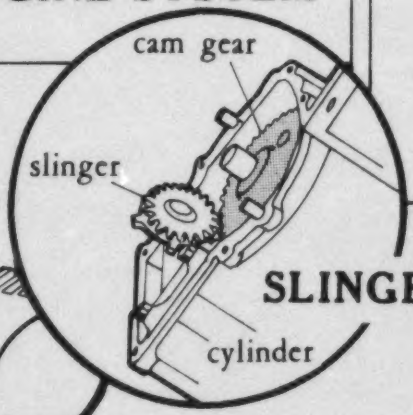
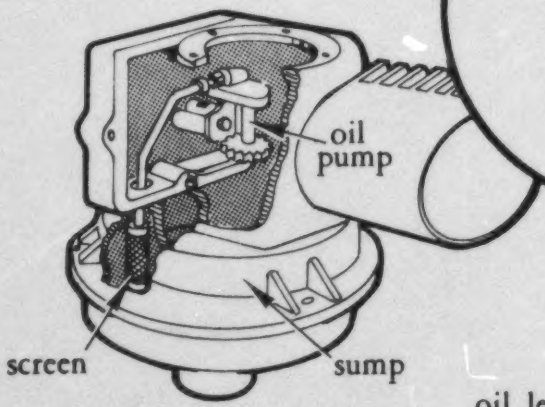
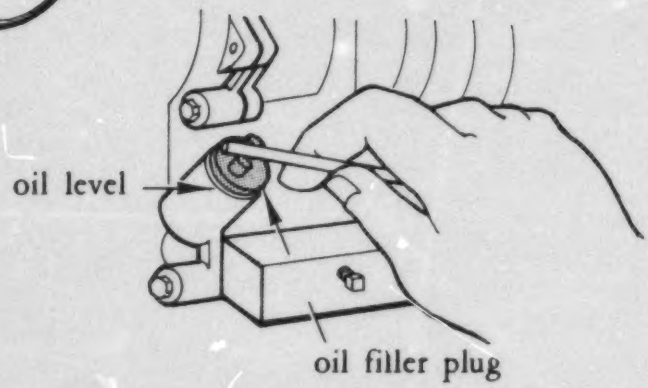


SLINGER SYSTEM



GEAR OIL PUMP



FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit B: Farm Truck and Tractor Maintenance

Topic 1: Operation and Safety

Suggested Procedures and Activities: After the class discussion a tractor and other farm machines and equipment may be used as exhibits to point out safety and non-safety features.

1. Importance of Practicing Safety

Most accidents are caused by carelessness on the part of the individual operator. Surveys on what causes accidents resulted in the following information: 88 percent of all accidents are caused by human error or carelessness, 10 percent are caused by faulty equipment, and 2 percent are caused by unavoidable happenings (lightning and other causes). Someone made this statement, "Most accidents don't just happen, they are caused by human error". Such general things as failing to study and follow instructions in the machine operator's manual, working when greatly fatigued or ill, or failing to keep the machine in a good operating condition and to correct hazards that may cause accidents can all be classed as human error.

There are about 2,000,000 disabling injuries caused by accidents in the U. S. each year in the major industries, and about 290,000 of these injuries are in the agricultural industry. Agricultural machinery is the major source of all recorded farm accidents.

Everyone hopes to live a life free of accidents and illness. A permanent injury may cause the reduction in earning power and lower the family standard of living. Many injured individuals experience going through a retraining program that is time consuming and expensive.

In order not to be "accident prone", the individual must become safety conscious if safety habits are to be developed. If something is being done dangerously, a positive safety attitude may prevent an accident. Such an attitude will change the method to a safer way.

Transparency No. 1

2. Operating the Tractor Safely

a. A tractor is similar to any other moving vehicle, in two ways; it is not dangerous when operated properly, and it has a center of gravity. The weight of the wheel

tractor is concentrated in front of the rear axle and midway between the rear wheels. The tractor will not likely tip over on a slope until the center of gravity is outside the near tire, unless it is turning. The centrifugal force on a tractor making a turn is outward; therefore, a tractor may tip over on the side while making a turn at a high speed. A tractor may be upset at eight miles per hour on level ground.

b. Safety rules to observe are as follows:

(1) Use the drawbar to pull a heavy lead. The tractor may tilt backward if the axle or seat bracket is used.

(2) Drive the tractor at a moderate speed. Many tractor upsets are caused by high speeds to and from work.

(3) Drive the tractor across ditches that have gradual slopes. The tractor may tilt backwards or sideways if driven into ditches with steep banks.

(4) Drive at slow tractor speed in tall grasses or weeds. A hidden rock, stump, or log can cause the driver to fall off the tractor or might make a sudden turn.

(5) Avoid driving along a steep slope. A small hole, bump, or turn may cause the tractor to tilt sideways. Use the engine to help brake the tractor.

(6) Use the tractor for only those jobs it is designed to do. Running errands and playing cowboy may cause a serious accident.

(7) Drive with utmost care in mud and on slippery ground. Wheels stuck in the mud can cause an accident. The chassis may revolve around the axle when power is applied.

(8) Work on attached equipment with the engine stopped, the tractor out of gear, and the brakes engaged. Such precautions may prevent an accident from occurring when hitching or working on attached equipment standing on a slope.

(9) Use rear wheel weights when using a front end loader on a tricycle tractor to avoid having the tractor tip forward.

(10) Consider the tractor as a one-rider vehicle. The operator should be the only person on the tractor when it is in operation.

(11) Avoid heavy and high speed traffic. It pays to haul the tractor rather than have it exposed to traffic conditions. Any slow-moving vehicle should use the slow-moving symbol day and night when traveling on roads or highways.

About 2/3 of all slow moving vehicles that are in collisions are hit from the rear by fast moving vehicles.

c. Other safety rules to observe are:

(1) Always start the tractor in neutral gear.

(2) Stop the engine and do not smoke when refueling the tractor.

(3) Never ride on the drawbar or dismount the tractor while it is still moving.

(4) Do not leave the engine running if the tractor is unattended.

(5) Wear snug fitting clothing when working around or on the tractor.

(6) Service the tractor with the engine stopped.

(7) Wait for a very hot engine to cool before adding water to the radiator.

(8) Ground the engine when doing belt work. The belt pulley should be motionless before putting on or removing the belt.

(9) Operate the tractor at night only if it is equipped with adequate lights and other warning equipment.

(10) Be sure that all safety and protection shields for moving parts and electrical wiring remain in place.

(11) Reduce speed and keep the tractor in gear when going down steep slopes or hills.

Most tractor and equipment accidents are caused by the operator failing to recognize the approaching danger or by the operator's carelessness. Accidents may be reduced or eliminated completely if the operator observes the safety rules for operating a tractor.

The best time to form correct and safe operating habits is when the operator is learning to operate the machine. Usually the operator's manual is studied at this time. The manual warns against unsafe habits and explains how the operator may develop safe practices.

Each year new safety devices are designed and placed on the tractor and tractor equipment. These safety devices are designed to protect the operator and others. If they are removed or made inoperable, the chance of being injured becomes greater. Actually, the best type of safety device is the operator.

3. Driving the Tractor

a. Starting the Movement - The foot brakes must be unlatched before the tractor is put in motion. There are several different types of latch releases. Some of the most common are: pull rod, lever, and toetrip. Some tractors have both brakes on one side, whereas others have a brake on each side of the engine. The PTO must be disengaged before starting the engine.

Idle the engine before engaging the clutch and shifting gears.

Disengage the clutch so that all power will be removed from the transmission, thus stopping the gears from rotating.

Shift the gear to the desired speed and engage the clutch. The rate of engine speed (quickness) for engaging the clutch will depend on the type and condition of tractor and the position the tractor is in at the time of movement. Clutches grab on some tractors, causing a sudden lunge forward. Engage the clutch easily.

A power shift can be shifted with the tractor in motion or on-the-go. The change in gear ratio is by a system of brakes and clutches that function together by hydraulic pressure. Change the gears one at a time.

If the tractor is equipped with a hand-shift transmission, the gears should not be shifted while the tractor is in motion. Some tractors are equipped with "gearshift stations", therefore, gears can be changed in the station while the tractor is in motion. The clutch disc and the transmission shaft must be stopped completely on most hand-shift tractors in order to avoid gear damage.

The tractor steering system is similar to an automobile. On most farm tractors a steering wheel is used to guide the front wheels. However, a tractor is equipped with individual brakes to assist the steering. A short turn may be made by braking one wheel.

b. Stopping the Movement - Retard the throttle to reduce the engine speed. Press down firmly on the clutch pedal to disengage the clutch. Shift the gear to the neutral position. The brakes may aid in bringing the tractor to a complete stop. The brakes are locked by pressing the brake pedal down. The speed-control lever should be set at fast idle if the engine is left running. If the driver is to dismount from the tractor, the engine must be stopped.

Transparency No. 2

4. Special Safety Practices to Observe When Operating Tractors and Other Machines

a. Many accidents are caused by the power takeoff (PTO). The most common accident is getting caught by the PTO shaft or rotating machine shaft. On some occasions an attached shaft will break or become disconnected and begin swinging dangerously behind the tractor.

b. Safety practices used to eliminate PTO accidents are:

(1) Master shields are used on tractors to protect the operator and others from coming in contact with the short PTO shaft. In order to completely eliminate the danger of coming in contact with the PTO shaft, a tubular guard shaft must be used over the stub shaft.

(2) Tunnel shields are used on the equipment shaft. This shield must extend from the equipment to the stub shaft of the tractor. Such shields may be nothing more than metal or other hard material guards. Some shields completely surround the shaft, whereas others are U-shaped covers supported by braces. Many of the integral-journal (tube) shields are made of plastic and are supported by bearings that cause them to rotate free of the main shaft.

(3) PTO accidents can be prevented by using the following practices:

(a) Disengage the PTO before stopping the engine and dismounting from the machine. Keep the PTO disengaged when servicing or repairing the machine.
(b) Operate the tractor only when the master shield is in place. It may be necessary to disconnect the shield when changing equipment, but it should be replaced immediately.
(c) Check the integral shield by rotating it by hand when the machine is stopped. Repair the shield if it or the bearings have been damaged.
(d) Tunnel shields will not operate properly if they are out-of-line. Align the shield and bolt securely in place.
(e) Refrain from stepping over a rotating shaft, even though it is protected by a cover.
(f) Properly phase or align the shaft universal joints if necessary. Some shafts cannot be reassembled improperly. However, some can be improperly assembled; therefore, they must be assembled in phase.
(g) One cause of shafts separating is that they fail to overlap enough and when one part of the unit (tractor and equipment) is higher than the other, the shaft comes apart. Therefore, use a shaft recommended for the proper connections.

c. Safety practices to observe when operating the tractor or machine brakes are:

(1) Check the brakes before putting the tractor in motion and after the tractor begins to move slowly. If the tractor is equipped with power brakes, press

each brake pedal to check the distance of travel. Lock the brakes together and operate the tractor slowly and use the brakes to determine if both are functioning the same. Use the operator's manual or service shop to make adjustments.

(2) Braking the tractor or machine:

(a) Use the individual wheel brakes to assist in steering the machine. If a short right turn is to be made, press the right wheel brake. This action slows the forward movement, resulting in a shorter turn.

(b) Lock the two brake pedals together when road driving the tractor. Pressure on the brake may upset the tractor at high speed.

(3) If fatigued or ill, begin braking the tractor or machine a few seconds sooner than when feeling fit. For example, when traveling 20 miles per hour, the machine will move about 7 feet for each 1/4 second.

(4) Check the operator's manual for proper braking methods when going down hill. The tractor may "freewheel", which means the engine will not help brake the downward speed.

d. Safety practices to observe when using lights and reflectors:

(1) When driving tractors and self-propelled machines on public roads at night, use the warning lights. These lights should be visible from both front and rear and mounted at the same level.

(2) When making turns, use the proper turning signal (visible from front and rear).

Most tractors and powered machines are equipped with red tail lights and reflector, work light, two amber warning lights on the rear, and two front lights.

(3) Use reflectors on equipment that is moved at night. If the equipment extends beyond the width of the tractor rear wheels, both flashing amber lights and reflectors may be used. This type of lighting system will require a special lighting system mounted on the equipment. Many types of reflectors and movable lamps are available for towing equipment.

(4) Use the machine on public roads at night only when both headlights are functioning. Set the lights so that they do not blind approaching drivers but are aimed properly in the path of the machine.

(5) Use mirrors that are designed for the machine. They may not be considered as standard equipment, but they are very valuable as a working and safety

device. If the machine is not equipped with mounting brackets, construct them to eliminate vibration and being hit by an obstacle and yet give adequate rearward visibility.

5. Common Causes of Fires

a. Tractor and equipment fires may be caused as follows:

(1) Electrical shorts in the electrical circuits.

(2) Fuel leaks due to loose or cracked lines.

(3) Trash accumulation, dust, and chaff on the machine.

(4) Broken or cracked sediment bulb. Most machines are equipped with metal or heat-treated glass bowls.

(5) Malfunction of the carburetor on a gasoline unit.

(6) Sparks from the exhaust.

(7) Careless machine operators. Smoking and allowing the engine to operate (run) when refueling are considered two very dangerous acts.

b. Fires in the shop and around the home are usually caused by the following reasons:

(1) Old and improperly installed electrical circuits and units.

(2) Failure to properly dispose of flammable objects and materials such as oil rags, wood scrap materials, and shavings.

(3) Igniting paints, varnishes, lacquers, paint thinners, gasoline, and oil.

(4) Pouring flammable liquids down drains. This practice can cause a very damaging explosion.

(5) Spraying flammable insecticides and other flammable sprays in the presence of open flame.

(6) Storing flammable fuels and special cleaning liquids in regular containers instead of safety cans.

(7) Drycleaning clothing and other textiles with naphtha, benzine, or gasoline.

(8) Failure to use trash containers and ash trays properly around the home and shop.

(9) Lack of proper ventilation where flammable materials are stored.

6. Classifying the Different Types of Fires

a. Class A Fires - Caused by wood, hay, paper, textiles, and rubbish burning. These fires can be quenched by water that is pressurized or nonpressurized.

b. Class B Fires - Caused by oil, grease, gasoline, paint, and other flammable liquids burning. These fires are extinguished by a smothering effect. A pressurized dry chemical or CO_2 (carbon dioxide) extinguisher is recommended.

c. Class C Fires - Caused by live electrical equipment such as heaters, motors, and switches. Pressurized dry chemical extinguishers are recommended for these types of fires.

7. Recommended Types of Fire Extinguishers

a. Soda-acid - This extinguisher is one of the most common types and is found in many public buildings. Water in this extinguisher puts out the fires. When it is inverted, a bottle of acid mixes with the solution of soda-water, causing a reaction that provides pressure for the stream of water and acid. Disadvantages- If solution gets on a person, it could burn or blind. Also it will damage fabrics, etc. Once inverted, this extinguisher cannot be stopped until completely discharged. If hose became clogged (for example by a wasp) there could be an explosion. It should be pressure tested and recharged each year. Use for Class A fires only. Dangerous if used on electrical fires or oil fires. Qualifed person must refill. This extinguisher is not recommended for vocational agriculture shops due to disadvantages listed above.

b. Foam Extinguisher - This extinguisher is useful for Class A and B fires. In case of a "spill" fire, the foam must be used to build a wall around the burning fuel and then it can be placed over the flame to extinguish it. Disadvantages - Experienced personnel are needed to use such extinguishers and may not be available when needed. Results will probably be poor in the hands of an unskilled person. Refilling requires an experienced person.

c. Pressurized water - Advantages - Can be used on fire intermittently as desired. A glance at the gauge lets one know if it is ready to use. Anyone can refill easily by adding water, closing lid, and supplying air pressure. Use on Class A fires.

d. Pressurized Dry Chemical - Advantages - The active ingredient is ordinarily baking soda and cannot harm humans or fabrics. A child 10 years old can effectively use this extinguisher. It can be used intermittently as desired. The pressure gauge indicates when this extinguisher is ready for use. Disadvantages- A residue (baking soda) is left. On electrical fires, involving a motor or electronic equipment, this residue might have to be removed. This extinguisher must be recharged by a qualified person. Use on Class A, B, and C fires.

e. CO_2 Carbon Dioxide - Advantage - Especially good on electrical fires because of no residue. Disadvantages - It is only effective at close range. Released carbon dioxide gas (which puts out fires) could injure a person because of the resulting low temperature (far below 0°). Sometimes a leaky valve will result in an extinguisher being empty when it is needed. An experienced serviceman must determine (by weighing) when the extinguisher needs a recharge. Refilling must be done by a qualified person. A funnel-shaped horn directs the fog discharge on the fire when held in a proper position. Use on Class A, B, and C fires.

Soda-acid and foam extinguishers must be completely cleaned and recharged once a year. The pressure should be tested every 5 years.

Cartridge operated extinguishers of all types are awkward to use and there is no way to determine whether or not they are in operating condition.

Important advantages of the newer recommended types (pressurized water and pressurized dry chemical) are the gauges that show at a glance if the extinguisher is ready for use. Also they require a minimum of maintenance, and recharging is needed only after use. Recommended extinguishers for general use are both the pressurized water and pressurized dry chemical (with gauge). For tractor and equipment and some household uses, a 2 1/2-pound pressurized dry chemical extinguisher with gauge is adequate.

Fire extinguishers must be kept in strategic places. For example, in or near welding, painting, woodworking, and machine repair areas. The extinguisher should be mounted on the wall at a proper height (about table top height) from the floor. Many prefer to mount extinguishers near entrances. There must be a vacated area around the extinguisher to make it accessible at all times.

8. Safety Precautions to Observe When Storing and Handling Fuels and Lubricants

Transparency No. 3

a. Storing and Handling Gasoline - Above ground gasoline tanks should be located as far as practical from buildings. The National Fire Protection Association recommends a minimum of 40 feet from the closest building. Tanks must be equipped with pressure-vacuum relief valves to prevent

dangerous vapor pressures. A safety valve between the hose and tank is a must. It stops the flow of fuel in case of fire. The NFPA standard is for all above ground tanks to be equipped with safety valves that close automatically in case of fire. An underground tank with a pump provides the safest storage. Rust is a problem on underground tanks; therefore, care must be taken not to damage the tank coating when installing it. Usually an asphalt tar or mastic coating is used. Place an underground tank and pump on a sloping and well drained area. This type of tank can be located within about a foot from the nearest building.

Locate smaller containers (55 gallon drums) of gasoline at least 40 feet from buildings. Store the drums outside closed buildings. Paint name of fuel on container. Never approach drum area with any flame that may ignite gasoline. Use pump to remove fuel from drum. Use an approved safety can to carry gasoline indoors. In this case, indoors means open ventilation. Most safety cans have a spring or valve to prevent the escape of vapors.

All gasoline stored above ground should be stored outside of buildings but placed under a shed. The tank should be painted white with gasoline printed on the front or side. White tanks stored under sheds lose much less gasoline than colored tanks exposed to the sun's rays. For example, a 300-gallon red tank will lose 9.6 gallons per month compared to a loss of 2.4 gallons per month for a white 300-gallon tank stored under a shed.

Transparency No. 4

b. Storing and Handling Diesel - Diesel overhead tanks should be placed at least 40 feet from the closest building. The National Fire Protection Association states that flammable vapors are released due to fuel spills while refilling machines and the storage tank. Diesel fuels may be stored the same as gasoline, in underground or overhead tanks, small drums, or safety cans. The containers should have the similar safety features as found on the gasoline containers, even though the fuel is not considered as flammable as gasoline. Most overhead diesel tanks are equipped with a vent pipe and filler cap. They do not have a special vapor pressure valve.

Kerosene can also be stored in the same manner as diesel fuel. It is not as flammable as gasoline, but it will give off flammable vapors when heated above 100 degrees F. Like gasoline and diesel fuel, it should never be stored in a closed building. An open shed should be used. Also, it should never by handled in open or glass containers.

Transparency No. 4

c. Storing and Handling LP-Gas

The LP-Gas tank should be placed a minimum of 50 feet from the nearest building. It should be 20 feet or more away from other fuel storage tanks. This distance gives adequate space for machines to travel between other structures and the tank.

Tanks are usually placed above ground in order that leaks can be readily detected by using a soap suds solution. However, LP-Gas tanks can be installed underground. Very rigid standards have been established by the National Board of Fire Underwriters regarding standards for storage tanks. A name plate is found on each storage tank, giving the tank pressure in pounds per square inch, the size in gallons of the tank, the name of the supplier, and whether the tank is to be used for underground or above ground purposes.

Some precautions to observe when refueling with LP-Gas are:

(1) LP-Gas is much heavier than air; therefore, refueling should not be over low places. Refueling should always be done outside of buildings. Use the vapor return line to equalize tank and machine pressure. The machine tank can be filled without vapor escaping to open air.

(2) Fill the machine (tractor or truck) tank only about 3/4 full. If the relief is forced to open, dangerous vapor escapes. Both automatic tank gauges and manually operated gauges are found on tractor tanks. The manual fixed tube-type gauges are operated by opening while the tank is being filled and closed after filling. Never permit any gauges to remain open after filling a tank.

(3) Refuel an LP-Gas tank when the engine is cool and stopped. Check the ignition switch to see that it is in the off position, and refrain from smoking until all vapors have been ventilated away.

9. Fire Prevention Practices

Most fires in and outside the farm shop are caused as the results of thoughtlessness of some individual. The best way to prevent losses caused by fire in the first place is to prevent the fire. Some fire prevention and control practices include:

a. Store flammables such as paint, lacquer, paint thinner, insecticides, and cleaning liquids in a separate small building. The location may be in the area of the fuel tank. If a small amount of these flammables are to be stored

in the shop, place them in a metal cabinet with some ventilation. All flammables should be stored in approved containers. Inspect paint and chemical cabinets occasionally for fire hazards.

b. It is best to dispose of oily rags, wood scraps, and shavings. Put these flammable materials in a covered metal drum. This drum may be located outside the shop.

c. Locate the fire extinguishers, fire blanket, and water connections to use in case of fire. Be familiar with the use of all fire equipment and control measures. Inspect the extinguishers periodically.

d. Use only cleaning solvents that are safe. Gasoline is one of the most dangerous liquids that can be used as a solvent. Guard against these and other flammable liquids from being poured in the sink or lavatories.

e. Do not ignite the oxyacetylene unit or turn on the arc welder in the area of flammable materials.

f. Many serious accidents are the result of cutting or welding containers which held flammable materials. Fill such containers with water and vent the space above the water level before applying heat to the container.

References:

1. "Fundamentals of Machine Operation, Agricultural Machinery Safety", Deere and Company, Moline, Illinois, 1974

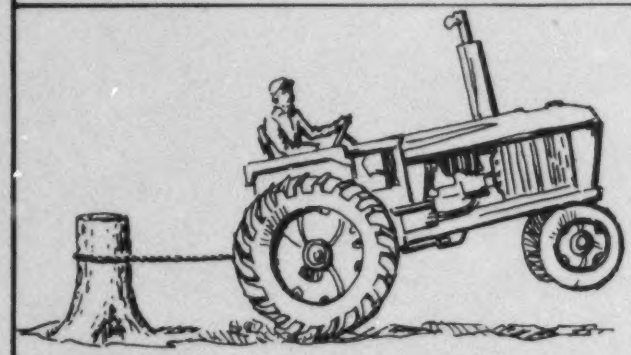
2. "Fundamental of Service - Fuels, Lubricants, and Coolants", Deere and Company, Moline, Illinois, 1970

3. "Fuels and Lubricants, Selecting and Storing", American Association for Vocational Instructional Materials, Athens, Georgia, 1973

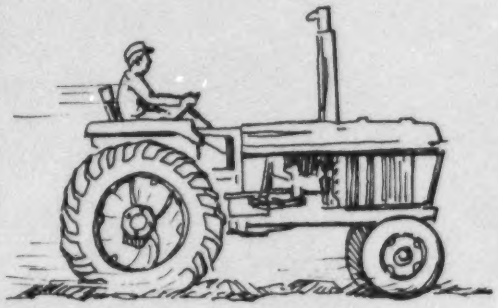
4. "Safety Practices in Agricultural Education", State Department of Education, Tallahassee, Florida, 1966

5. Silletto, Thomas A. and Hull, Dale O., Safe Operation of Agricultural Equipment, Hobar Publications, St. Paul, Minnesota, 1975

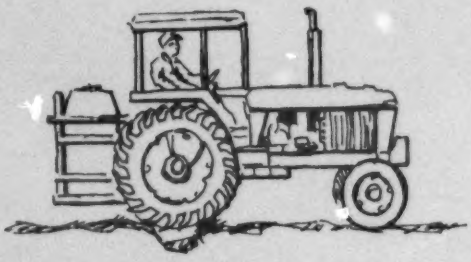
TRACTOR SAFETY



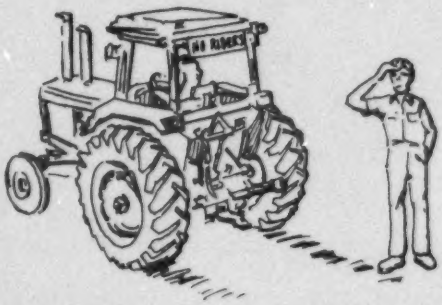
improper use of the draw bar



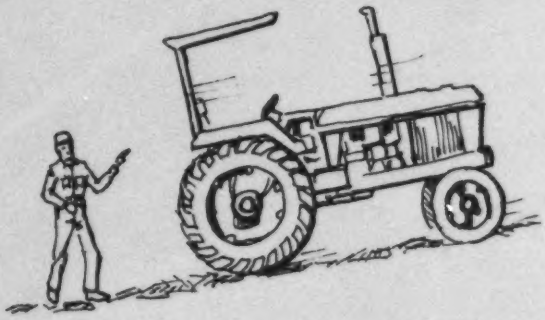
do not drive tractors to and from work at high speeds



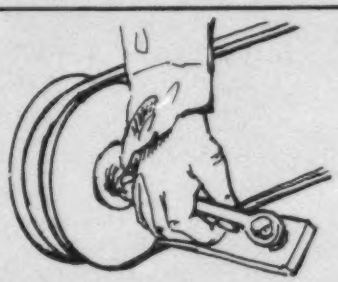
do not drive fast over narrow ditches



the tractor is a one rider vehicle

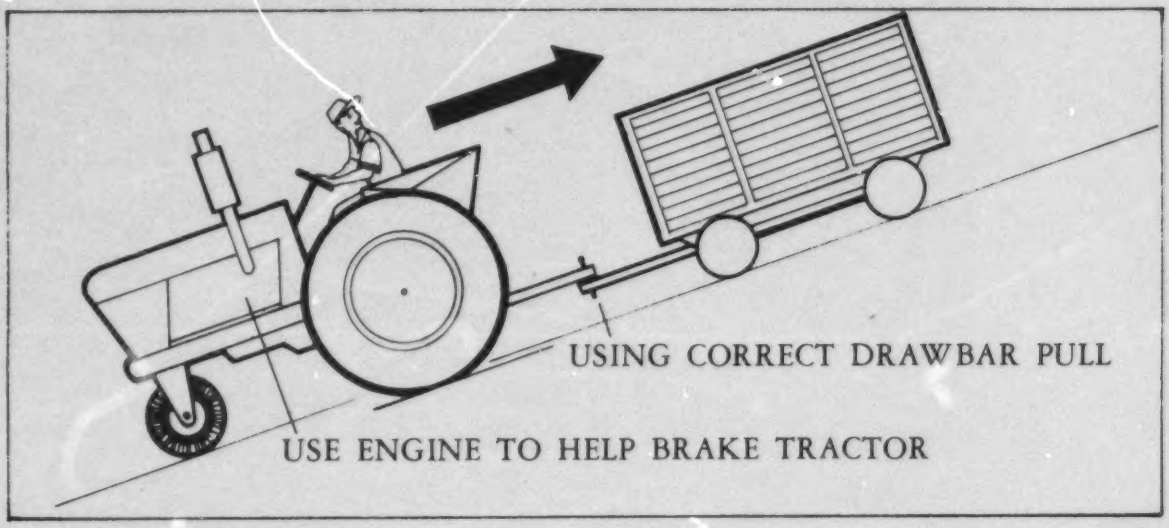


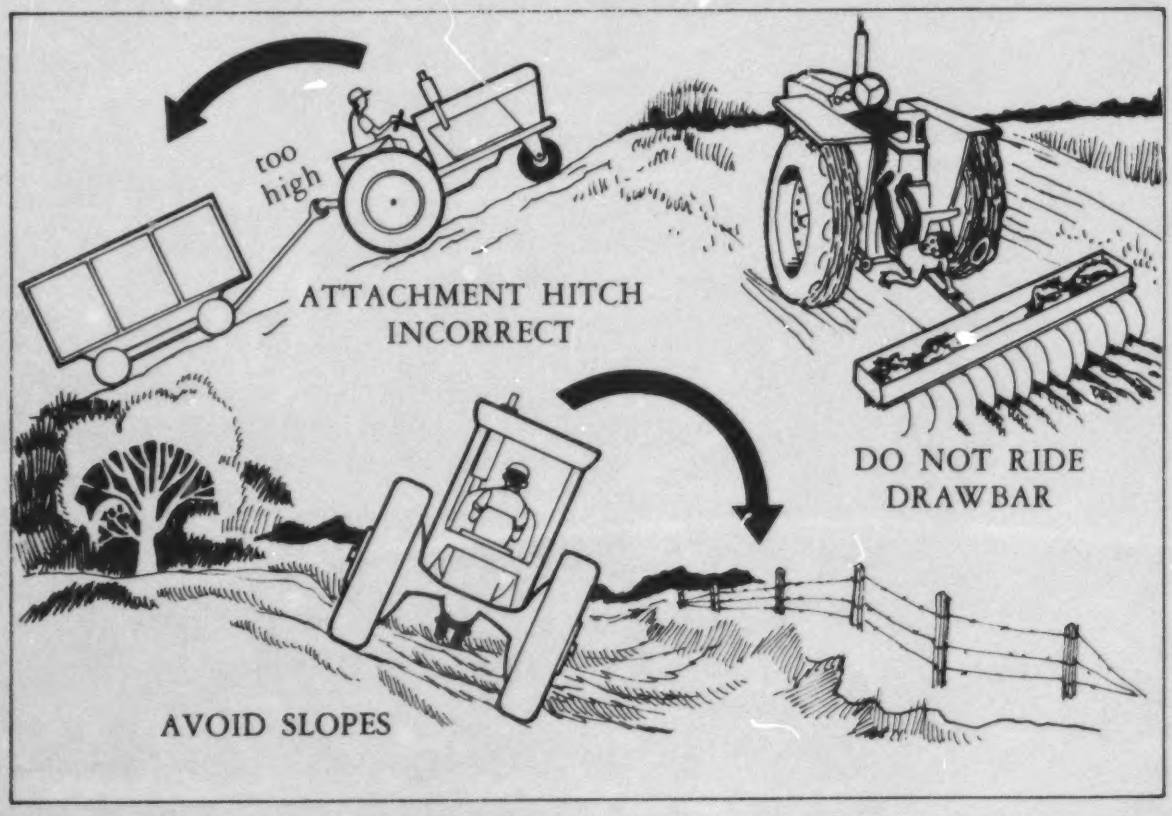
do not park a running tractor



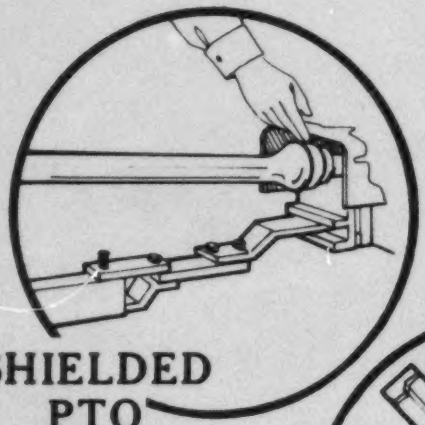
be alert when working near belts in motion

OPERATING TRACTOR

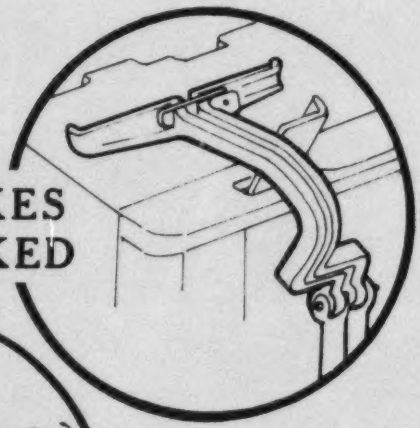




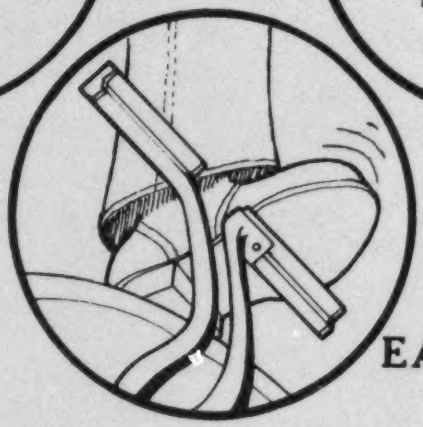
OPERATING TRACTOR



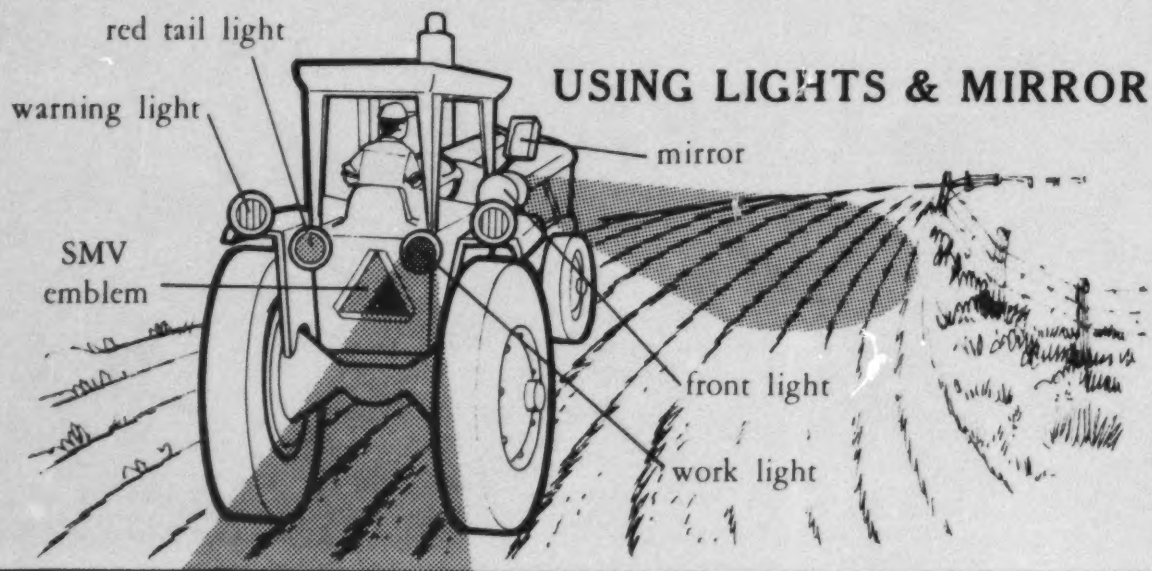
SHIELDED PTO



BRAKES LOCKED

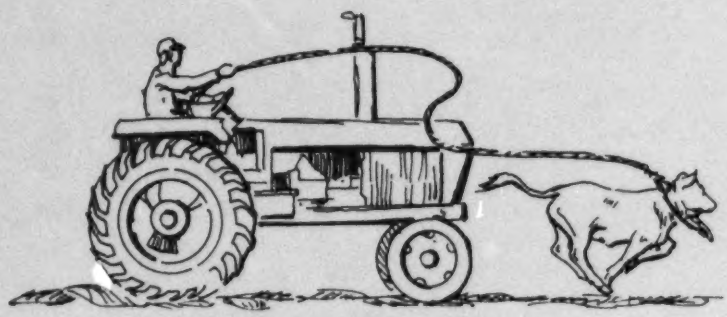


CHECK EACH BRAKE

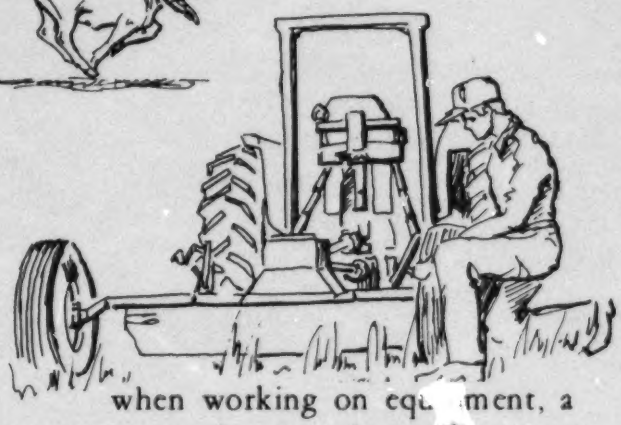


USING LIGHTS & MIRROR

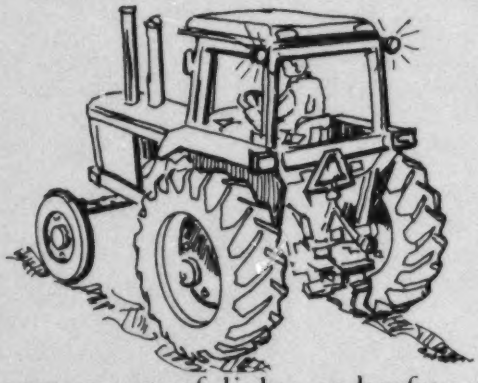
TRACTOR SAFETY



improper use of tractor

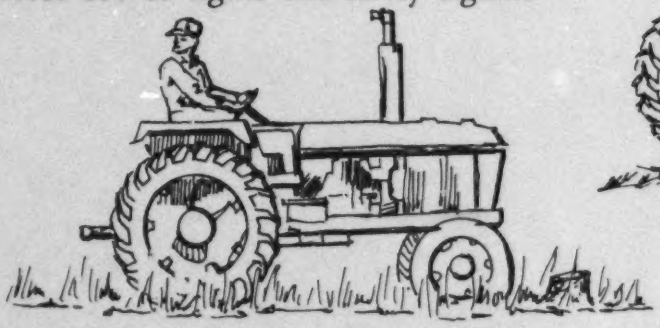


when working on equipment, a stopped tractor is a safe tractor



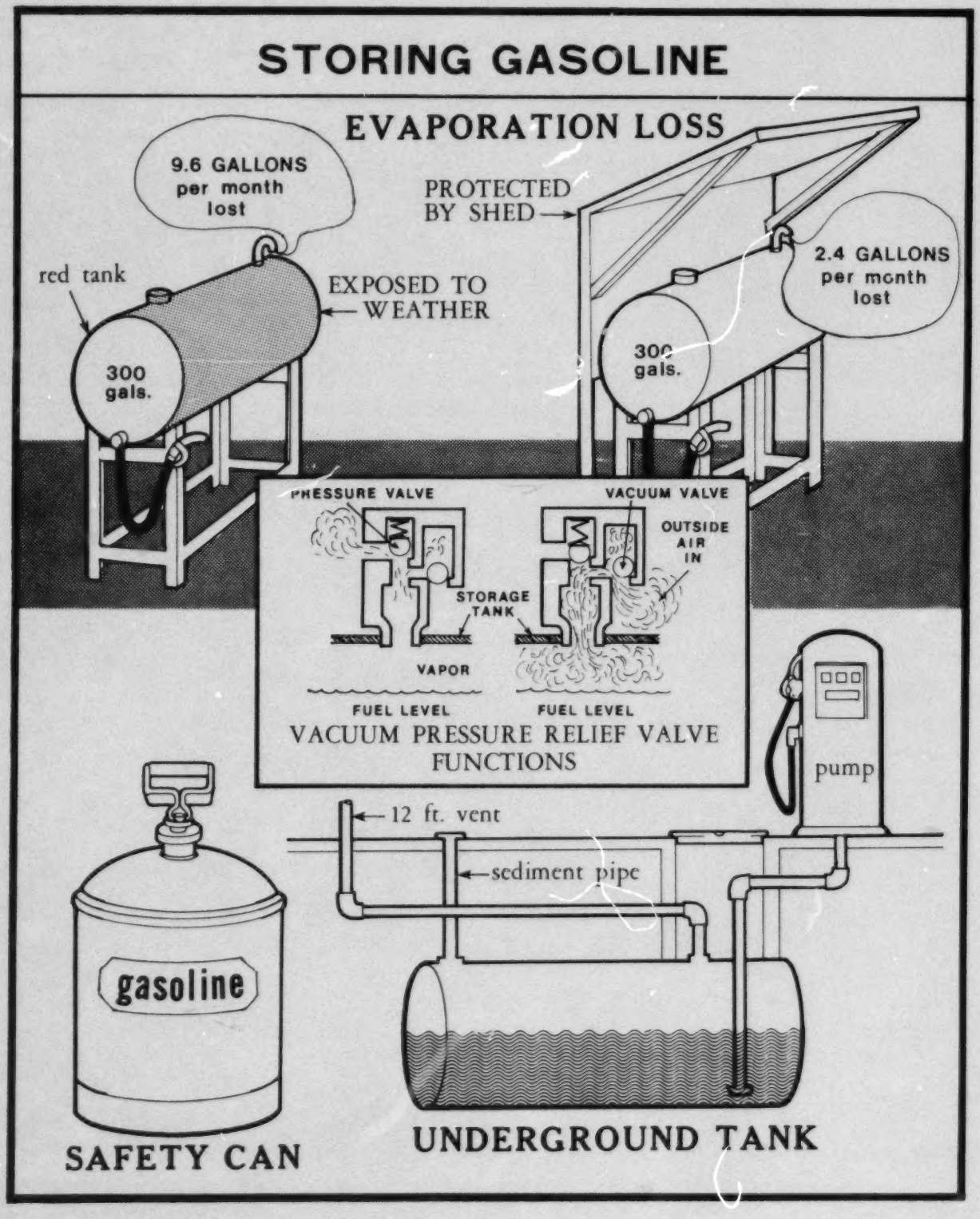
correct use of lights and safety signals

rear wheel weights help balance the load

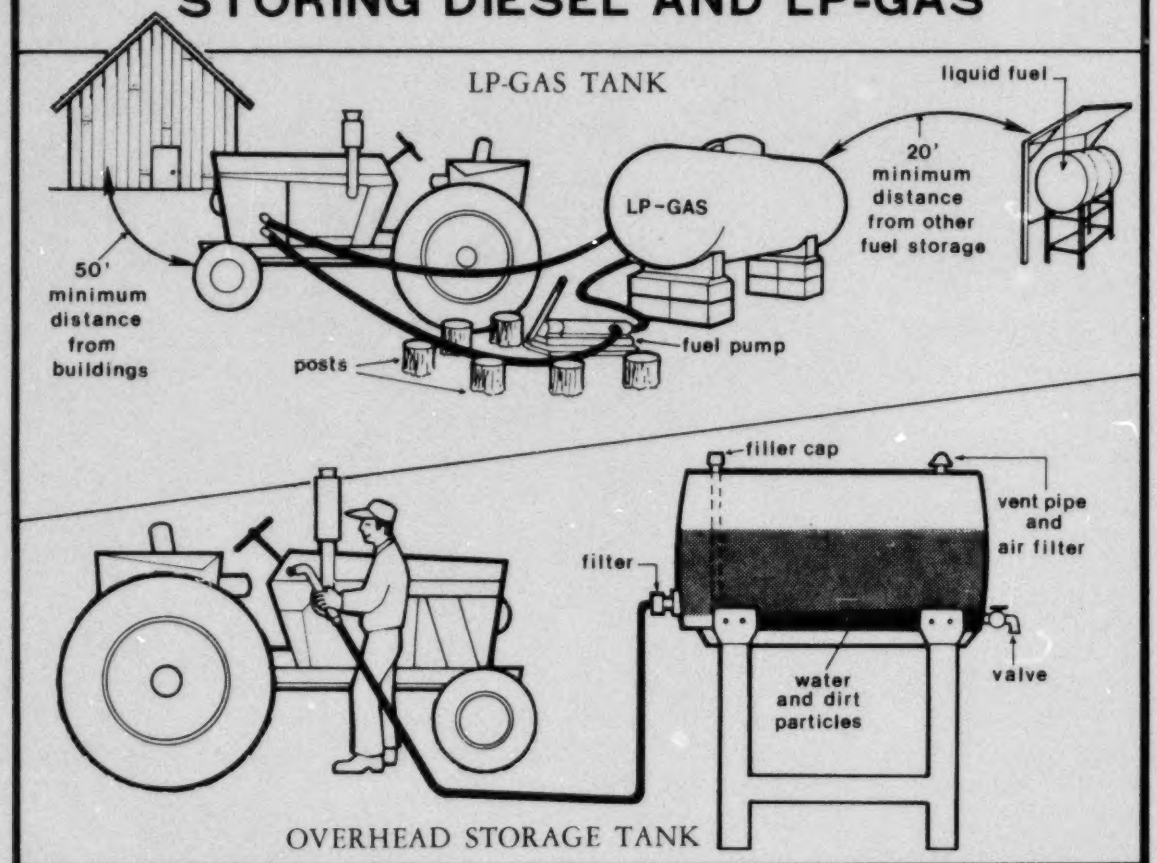


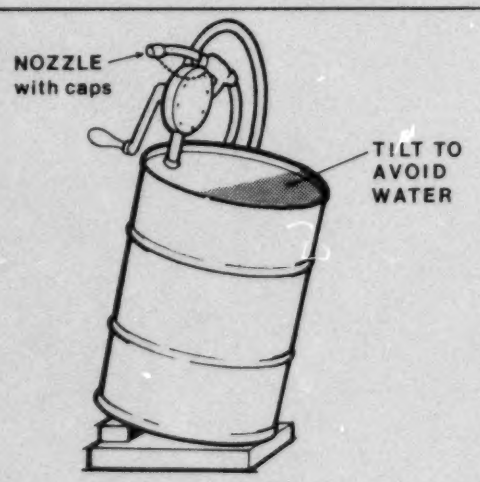
hidden objects cause accidents

STORING GASOLINE



STORING DIESEL AND LP-GAS





55-GALLON DRUM

5-GALLON SAFETY CAN

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit B: Farm Truck and Tractor Maintenance

Topic 2: Daily Care

Suggested Procedures and Activities: Transparencies, filmstrips, and slide film can be used as teaching aids when presenting the lesson on daily care of a tractor. A tractor and large wall charts can also be used during the class discussion.

1. The Importance of Tractor Maintenance

A tractor is designed to give long and satisfactory service if it receives the proper care throughout its useful life. Many tractors remain in operation for twenty-five years and even longer.

In order for a tractor to give long service it must receive the proper daily care when it is being used. The best guide to follow for a good maintenance program is the operator's manual. This explains which parts need to be checked and serviced, according to the length of time the tractor is in operation. It may point out maintenance practices that should be observed at the beginning of each operational day.

2. Operation Devices Which Protect the Tractor

The tractor manufacturer provides instructions, instruments, and gauges to protect the machine while it is in operation. These devices identify troubles that appear in vital parts of the engine. The instruments and gauges relay messages, and a competent operator watches them while driving the tractor. The gauges and their functions are:

Transparency No. 1

a. Heat Indicator - This gauge indicates the temperature of the liquid in the cooling system.

b. Oil Gauge - This dial indicates the oil pressure which is regulated by the circulation of the oil.

c. Ammeter - This dial points out any trouble in the circuits. It gives the amount of current flowing from the battery.

d. Hour Meter - Most tractors are equipped with meters which indicate the number of hours of use.

Tractors are provided with special air cleaners, brakes, lights, guards, bearings, grease fittings, seals, wheel weights, filters, and many special gear ratios to make it one of the most protected machines in operation. Yet, many tractors are disabled or destroyed through unnecessary wear, mechanical troubles, collisions, breakage, and plain crack-ups.

3. Special Care Practices

a. All tractors have certain parts that need daily attention. Most of these parts are checked every ten hours (daily) the tractor is operated. Under certain conditions some parts of the tractor are checked every five hours. For example, a tractor operating in mud or on a very dusty location should be checked more often than one operating under normal conditions.

b. A new or overhauled tractor requires a different kind of daily care from one that has been in service for several months.

A new or overhauled tractor is operated at less than one-half load at full throttle for the first ten-hour period. For the second ten hours, it is operated at one-half load. The new or overhauled tractor should be operated at about one-half load for five to six ten-hour periods before operating at a full load.

The motor on a new or overhauled tractor should not be idled for a long period of time. Damage may occur to the cylinder walls or rings due to insufficient lubrication. A corrected fast idle speed should eliminate overspeeding of the engine. A new or overhauled engine should not be overspeeded.

c. Before a tractor is put under a full load, it should be allowed to warm-up. The warm-up period is most important if there is a high moisture content in the air or if the weather is very cold. Even during warm weather, it is advisable to idle the engine a few minutes before operating the tractor at a full load. Much of the engine wear occurs between the time the engine is started and the time it reaches the proper operating temperature. It may take the tractor twenty to thirty minutes to reach a proper operating temperature of 180° to 190°.

4. Daily Care Practices

Transportation vehicles are usually serviced according to the miles covered. Tractors are serviced according to the number of hours they run. Most of

the same operating parts will be checked during each check period. The most important service periods and services performed are:

Transparencies Nos. 2, 3, and 4

a. After the first 10 hours of operation

Check the crankcase oil level, liquid in the cooling system, and fuel tank.

Check the fan, generator, and water pump belts.

b. After each succeeding 10 hours of operation

Check the crankcase oil level.

Lubricate fittings that require lubrication (steering, brake and clutch pedals, etc.).

Clean air cleaner - Dry or oil type.

Check the water level in the radiator. If the coolant is low, fill to about two inches below the neck.

Check the pressure in the tires. The change in weight of tractor equipment will make it necessary to change the air pressure.

Check the fuel level in the tank. Full tanks collect less moisture than empy tanks.

Check tractor for broken and worn parts, loose nuts, and bent brackets.

Transparencies Nos. 5, 6, and 7

c. After 50 hours of operation

Check fan shaft bearings and water pump bearings for lubrication. Lubricate these bearings according to the manual directions.

Check crankcase oil, drain oil, and refill.

Check hydraulic fluid filter and replace element if necessary.

Check pneumatic tires for proper pressure.

Check radiator core, water pump, fan and generator belts.

Check flexible rubber connections for loose fitting or leakage and V-belts.

Check and tighten cylinder head bolts with torque wrench on LP gas engines.

Check the fluid level in the battery.

Check and lubricate clutch release mechanism.

Check and service dry-type air filter.

Transparencies Nos. 6 and 7

d. After 100 hours of operation

Check the crankcase oil and replace oil filter with oil change. In some tractors it is recommended the oil and filter be changed every two weeks.

Check and lubricate the clutch pedal, brake pedals, and clutch release bearings.

Check the cylinder head bolts and tighten to proper torque. Also, check valve clearance.

Check and clean cylinder head breather caps.

Check the crankcase breather and clean or replace it.

Transparencies Nos. 7 and 8

e. After 250 hours of operation

Check, drain, and refill crankcase.

Check and clean fuel sediment bowl.

Check and clean hydraulic screen and replace filter.

Check and replace lubricating oil filter.

Check and lubricate all points.

Check the brakes and clutch for adjustment.

Check and adjust spark plugs.

Check breaker points, adjust and clean chamber.

f. After 500 hours of operation

Check and repack the front wheel bearings.

Check hydraulic system and change oil.

Check the steering gear housing and change the oil.

Check the cooling system, drain and refill.

Check the timing of the tractor.

g. After 1000 hours of operation

Check transmission, differential, and final drives. Drain and refill these parts.

Check all other parts and make tune-up adjustments.

5. Results of Inadequate Maintenance

a. Dirty air cleaners

b. Dirty crankcase breathers

c. Low tire pressure

d. Low liquid level in battery

e. Improper valve adjustment

f. Ignition points pitted

g. Dirty spark plugs out of adjustment

h. Dirty crankcase oil

i. Liquid low in radiator

j. Brakes out of adjustment

k. Dirty fuel pump sediment bowl

l. Bearings lack lubrication

m. Hydraulic oil level low

n. V-belts loose

6. Storage and Specific Uses

a. The tractor should be placed under a shed when it is not in use. Weather conditions such as high humidity, rain, sunlight, and very strong wind that moves dust can affect exposed tractor parts. Plastic, paint, rubber, and fibers are affected by weather conditions.

b. Tractors are made to perform specific types of jobs and they should not be used to perform work that will endanger the future use of the machine.

c. If a tractor is not cared for properly, the maximum horsepower will be reduced and the fuel consumption will increase. Proper care of a tractor will save money and avoid costly breakdowns.

References:

Promersberger, William J. and others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971

Stone, Archie A. and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, NY, 1967

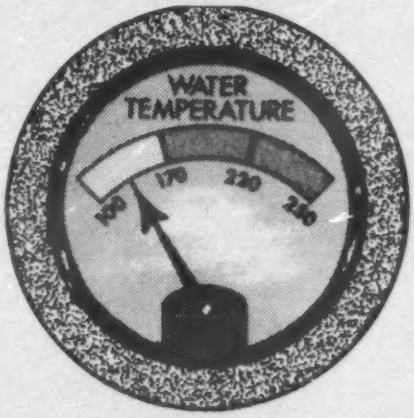
"Tractor Maintenance-Principles and Procedures", American Association for Vocational Instructional Materials, Athens, GA, 1975

"Tractor Operation and Daily Care", American Association for Vocational Instructional Materials, Athens, GA, 1970

GAUGES TO AID IN OPERATION

AMPERES GAUGE

WATER TEMPERATURE GAUGE

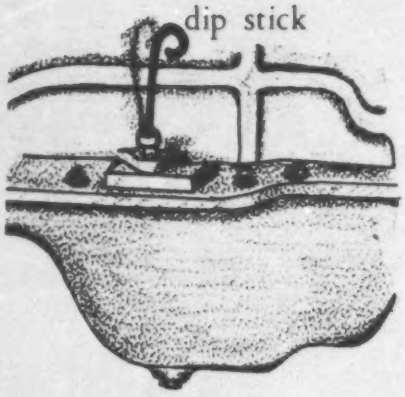


OIL PRESSURE GAUGE

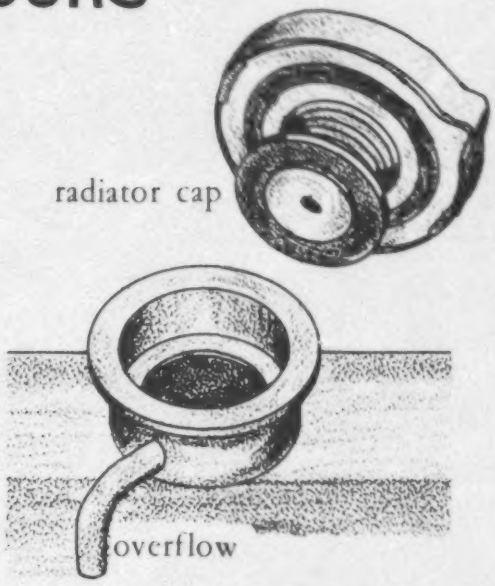
TRACTION BOOSTER GAUGE

MILES PER HOUR AND HOUR USE GAUGE

WHERE TO CHECK AFTER FIRST TEN HOURS

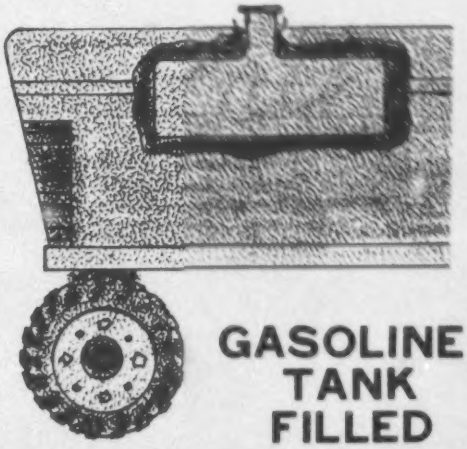


CRANKCASE OIL LEVEL MAINTAINED



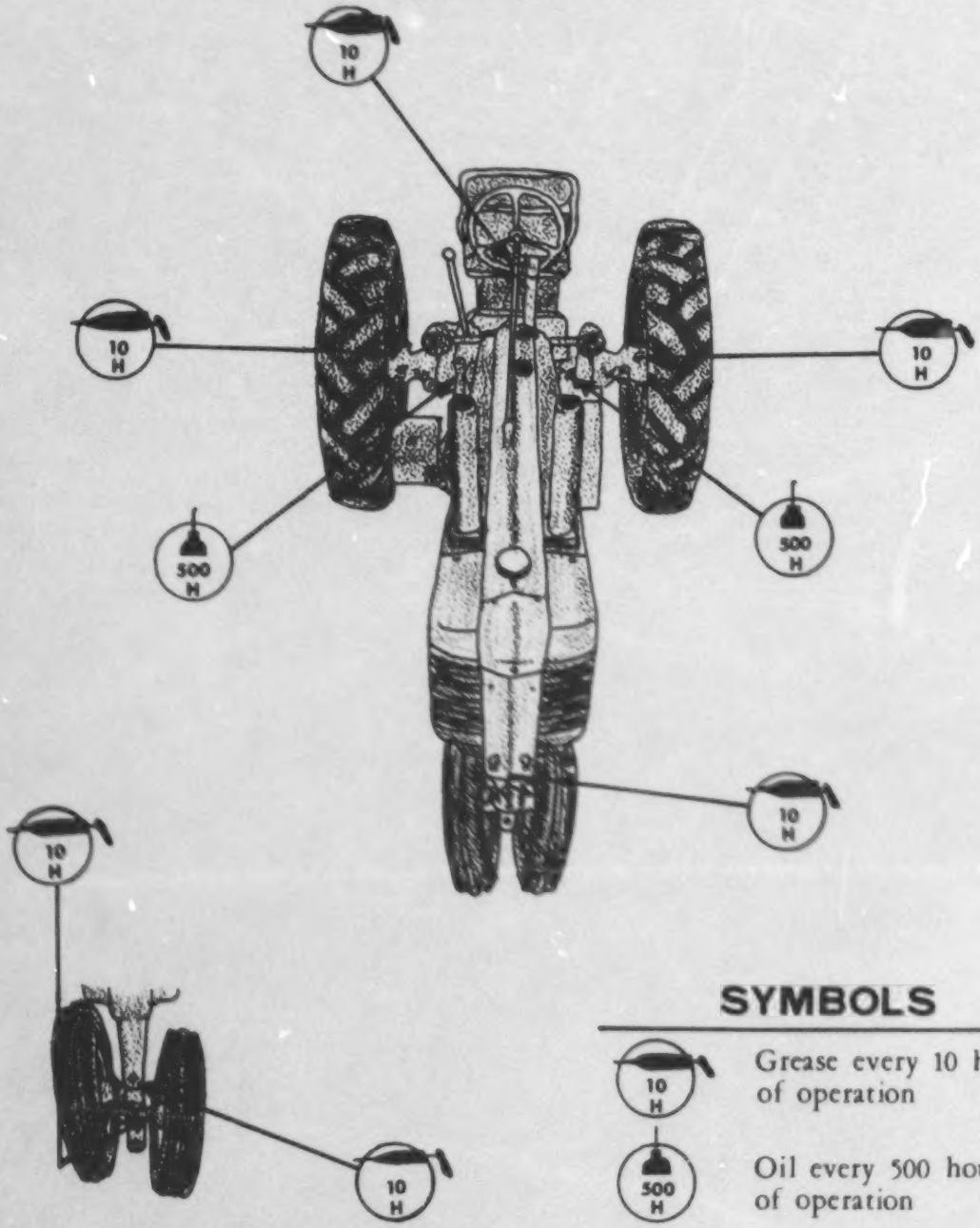
RADIATOR LIQUID LEVEL MAINTAINED

BELT TENSION



GASOLINE TANK FILLED AT END OF DAY

LUBRICATION ACCORDING TO HOUR USE

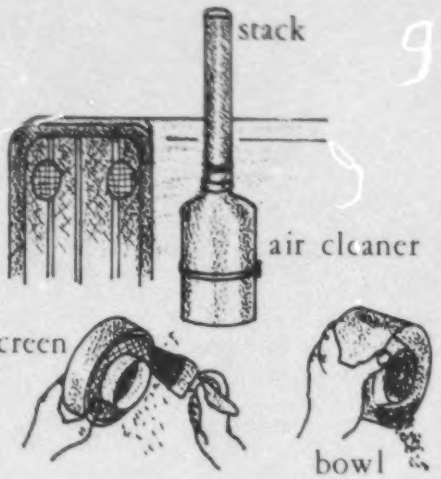


SYMBOLS

10 H — Grease every 10 hours of operation

500 H — Oil every 500 hours of operation

CHECK FILTERS AND TIRES



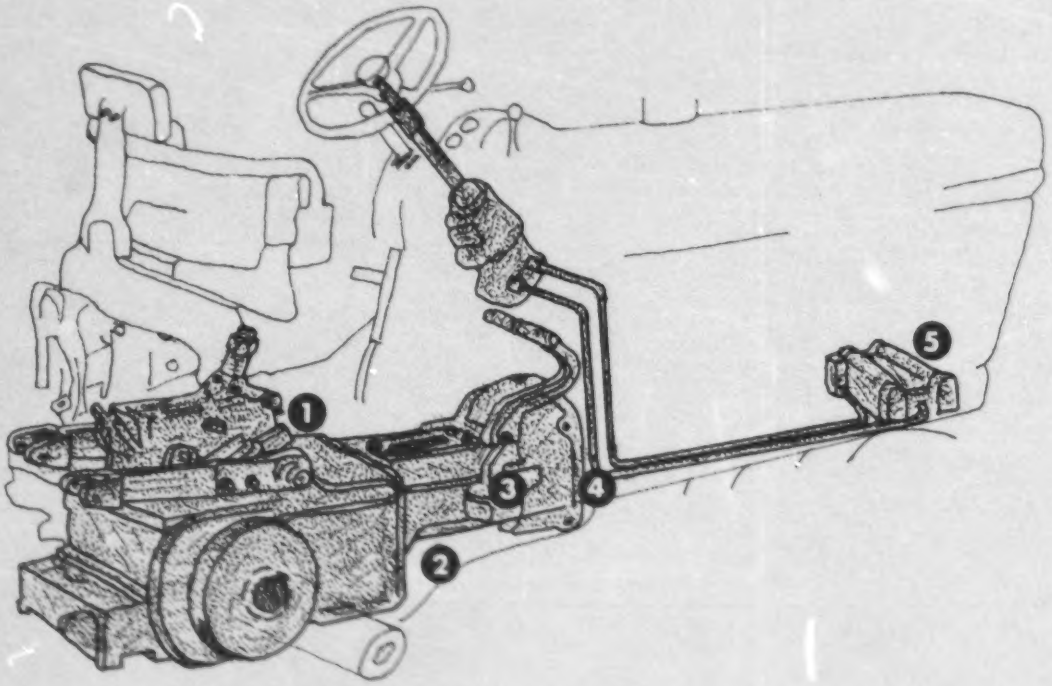
OIL-TYPE AIR FILTER DRY-TYPE AIR FILTER

PROPERLY INFLATED TIRE

OVER INFLATED TIRE

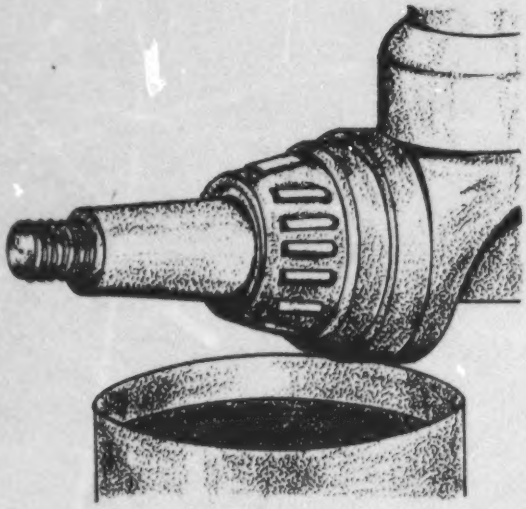
UNDER INFLATED TIRE

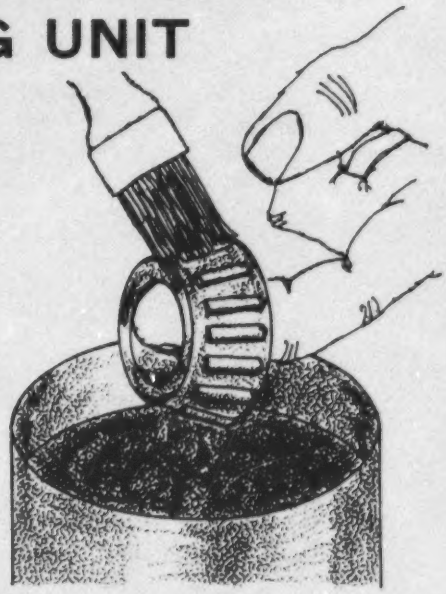
TRACTOR HYDRAULIC UNIT



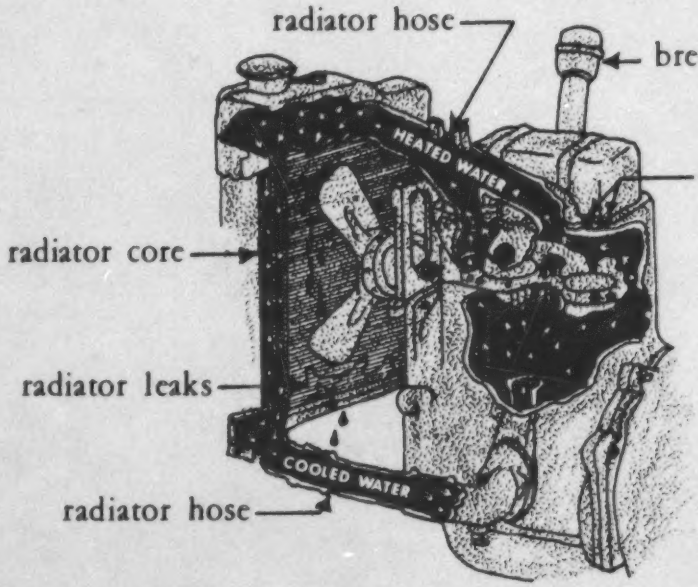
1. CONTROL SYSTEM FOR IMPLEMENTS
2. TRANSMISSION
3. POWER BRAKE UNIT
4. TORQUE CONVERTER
5. POWER STEERING UNIT

FRONT WHEEL BEARINGS AND COOLING UNIT



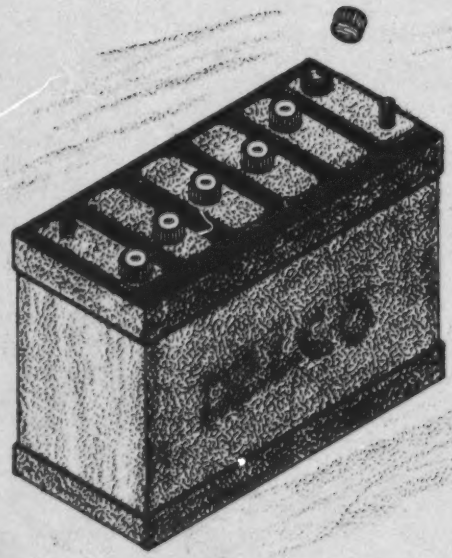


CLEANING FRONT WHEEL BEARINGS

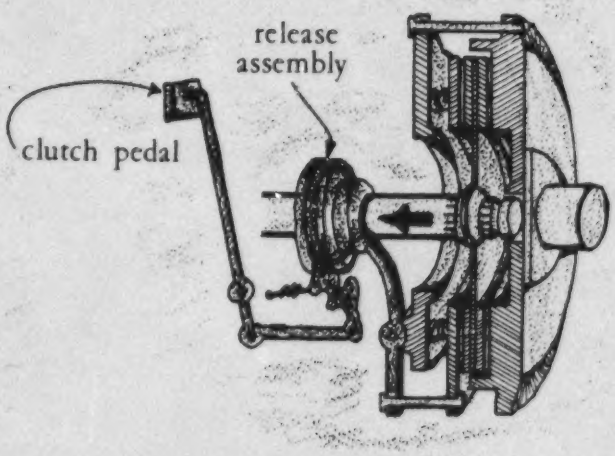


CHECKING THE COOLING SYSTEM

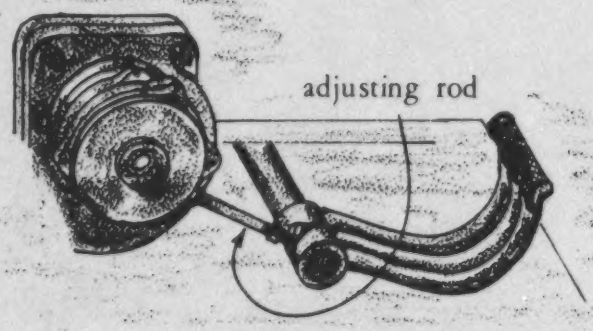
CHECKING BATTERY, CLUTCH, BRAKES AND FILTER



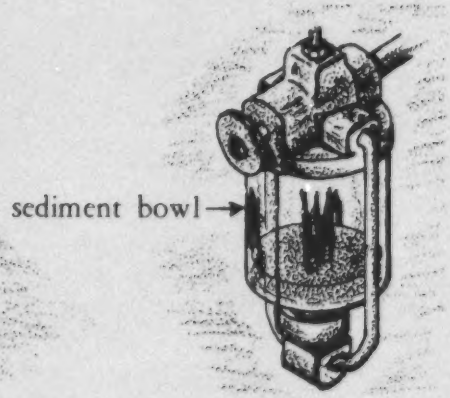
CHECKING FLUID IN BATTERY



LUBRICATE CLUTCH RELEASE MECHANISM

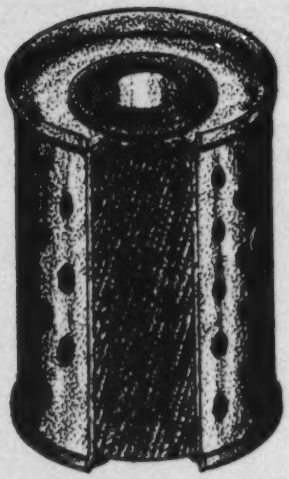


ONE TYPE OF BRAKE ADJUSTMENT

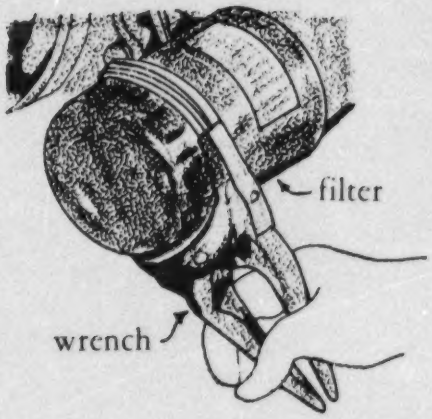


SEDIMENT UNIT

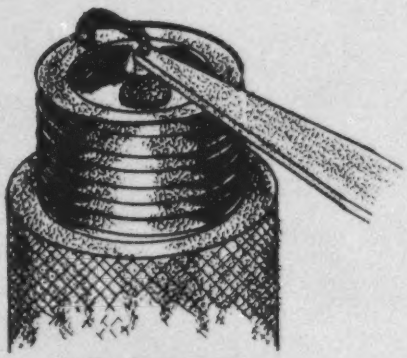
CHECKING FILTER, SPARK PLUGS AND IGNITION POINTS



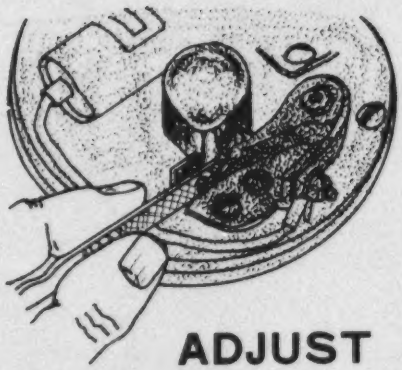
ELEMENT OF SURFACE TYPE FILTER



REPLACEABLE TYPE FILTER



ADJUST SPARK PLUGS



ADJUST BREAKER POINTS

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit B: Farm Truck and Tractor Maintenance

Topic 3: Servicing Air Cleaner Assembly

Suggested Procedures and Activities: Disassembled oil and dry-type air cleaners will be helpful in discussing the servicing of air cleaners. Transparencies may also be helpful as a teaching aid.

1. The Purpose of the Air Cleaner

The air cleaner is one of the most important parts of standard equipment found on a tractor. It furnishes clean air to the engine by preventing dust, chaff, and other foreign material from passing through the carburetor, manifold, intake valves, and into the cylinders.

Air free of abrasive particles reduces the wear on cylinder walls, piston rings, rod bearings, and valves. If these abrasive particles are not removed, damage is done to the engine before the dust reaches the oil stream, where it is removed by the oil filter.

A tractor may use as much as 9,000 gallons of air per gallon of fuel under normal operating conditions. All air enters the carburetor after passing through the air cleaner.

Transparencies Nos. 1 and 2

2. Types of Air Cleaners

a. Oil-Bath Type - This is the most common type of air cleaner found on modern tractors. The method in which the cleaner functions is as follows:

(1) The incoming air flows into the cleaner oil cup.

(2) Air forced on the oil causes a mixture of air and oil spray to be carried up into the separating element. The element is made up of baffles and metal mesh.

(3) The fine dust particles carried by the air are trapped by an oil film as the air changes directions many times in the separating element.

(4) The dust particles are washed from the screen into the oil cup by the oil spray.

(5) The dirt particles settle to the bottom of the cup as the clean air passes upward through the filtering element into the engine.

Oil bath type air cleaners are found on tractors that require a large amount of air for operation.

b. Dry Type Air Cleaners - The dry type air cleaners are either attached to the carburetor or manifold. The filter media is either heavy treated paper, layers of cloth, or felt. The filtering area is increased in the filtering element by the material being folded like an accordion. Clean air is produced in the dry type cleaner in the following manner:

(1) Air enters the element through an air inlet.

(2) The design of the element fins causes the air to circulate in a centrifugal motion around the element.

(3) As the air reaches the bottom of the element, the dirt is separated from it and deposited into the dust cup.

(4) As the air flows through the filter element, material and the remainder of the dirt are removed.

Dry type air cleaners were used only on the small engines several years ago, but recently they are found on some of the larger type engines. The parts of the air cleaner are: inlet pipe, air cleaner body, filter element fins, baffles, and dust cup.

Many tractors are equipped with a pre-cleaner. Usually the pre-cleaner is located at the end of the pipe. They remove the large particles of dust, depositing the particles in a collector bowl before they pass into the main cleaner. The pre-cleaner extends the cleaning intervals by reducing the load on the main air cleaner.

3. Advantages and Disadvantages of Using the Dry Type Air Cleaner

a. This type of cleaner does not require cleaning as often. An oil-bath type cleaner is cleaned daily (each ten hours), whereas the dry type cleaner may be cleaned at 50-hour intervals.

b. The element may be cleaned with air and/or water. It is not necessary to use a solvent to clean the air cleaner; therefore, it is not as messy as cleaning an oil-bath type filter.

c. There is less danger of lint or chaff clogging the air passages.

d. In case the filter is not serviced as recommended, the air movement through the filter may be restricted, causing the engine to lose power, give off black smoke, and use more fuel.

If the tractor is equipped with an air cleaner restriction gauge, it will indicate when the air cleaner needs servicing.

4. Servicing the Oil-Bath Type Air Cleaner

The steps to follow in servicing the oil-bath type air cleaner are:

a. In order to prevent dust particles from being drawn into the engine, it must be stopped before the air cleaner is serviced.

b. The oil cup is removed and inspected for a dirt deposit. If the accumulation of dirt is about one-fourth inch deep or the oil appears heavy, the cup should be emptied and refilled with the proper grade of oil. It is necessary to fill the cup to the proper oil level, after it has been cleaned.

c. The bottom of the screen should be inspected for an accumulation of chaff and other foreign material. The foreign material should be removed before replacing the oil cup.

d. The entire air cleaner should be removed at least once per year and thoroughly cleaned with kerosene or fuel oil.

The oil-bath type air cleaner should be inspected after each ten hours of operation. It is a good practice to inspect the air intake stack at the same time the oil cup is being inspected.

Transparencies Nos. 3 and 4

5. Servicing the Dry Type Air Cleaner

The following steps should be followed in servicing a dry type air cleaner:

a. The engine must be stopped before servicing the air cleaner. If not,

dirt or dust can be drawn into the engine while the filter element is being removed.

b. If the air cleaner is equipped with a rubber valve (dust unloader), it should be opened to release the dust particles. If the dust unloader is damaged, it should be replaced.

c. It may be necessary to remove the hood or grill in order to provide access to the air cleaner.

d. The dust on the exposed end of the air cleaner should be wiped off with a rag before removing the element.

e. The end cap may be held in place by a hand screw or a clamp. The screw or clamp is removed to free the cap.

f. A clean rag should be used to wipe the area around the element and to remove the dust from both the cap and baffle, if end cups are found on the air cleaner.

g. If the rubber gasket on the end of the filter element is damaged, the entire filter element must be replaced.

h. After the filter element is removed and examined for defects, it should be cleaned, unless the element is to be replaced. The methods of cleaning the filter element are:

(1) Tap the element to loosen the dirt. Shake the element to remove the loose dirt.

(2) Place the nozzle of a compressed air hose about one inch from the filter element and rotate the element until it is clean. The nozzle pressure should not exceed 100 pounds per square inch.

Wash the element with water and detergent. First, clean away dirt with water or air and then wash with warm water and detergent. Rinse the element with clean water and allow 24 hours for drying.

Reassemble air cleaner in the reverse order of disassembly.

6. Servicing the Oil-Soaked Element Type Air Cleaner

The oil-soaked element type air cleaner is found on small tractors or engines that require a large amount of air. It is not considered to be a major type of

filter. This type does not clean as well as the oil-type filter and consequently there is limited use of it.

The steps in servicing the oil-soaked element type air cleaner are:

a. The engine must be stopped while servicing the air cleaner.

b. The oil-soaked filtering element is removed and washed in a safe solvent. Dust particles are removed from the fibrous element in the process of washing.

c. Excess solvent is removed by shaking the element after washing. The element should be allowed to dry thoroughly before soaking it in oil.

d. The filtering element is replaced in the same order that it was removed.

This type of air cleaner requires frequent attention. Although it may not be checked daily, it should be checked more frequently than the dry type air cleaner, when operating under similar conditions.

References:

"Farm Tractors - Basic Principles, Operation and Maintenance", Engineering Bulletin FT-53, American Oil Co., Chicago, IL, 1968

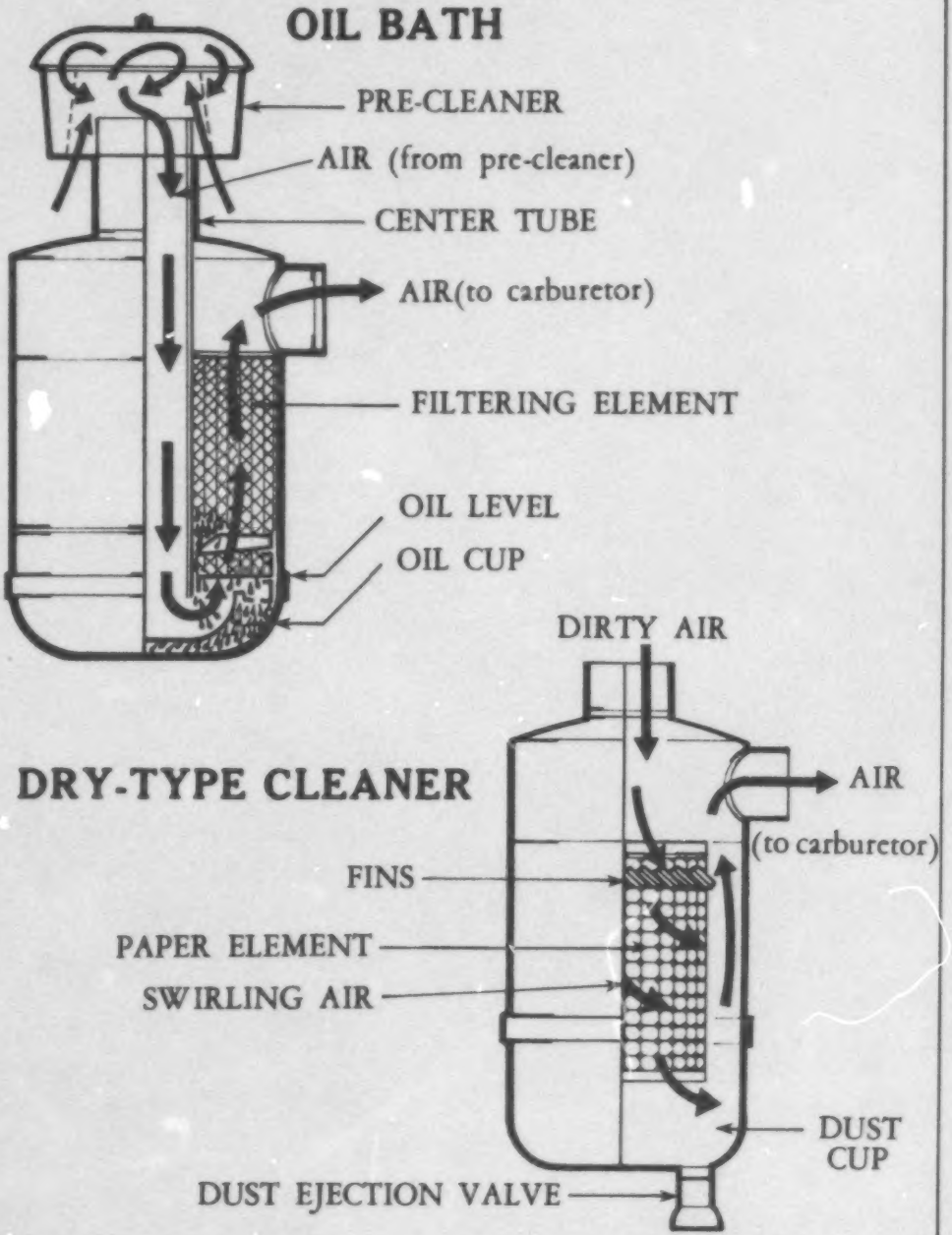
"Fundamental of Service Engines", Deere and Co., Moline, IL, 1972

"Gulf Farm Tractor Guide", Gulf Oil Corp., Houston, TX, 1970

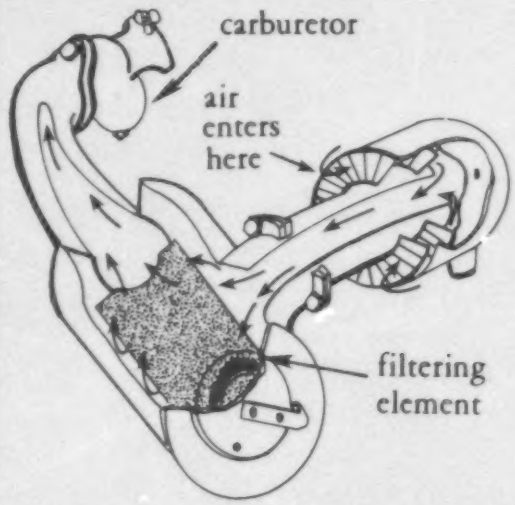
Promersberger, William J. and others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971

"Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Ga, 1975

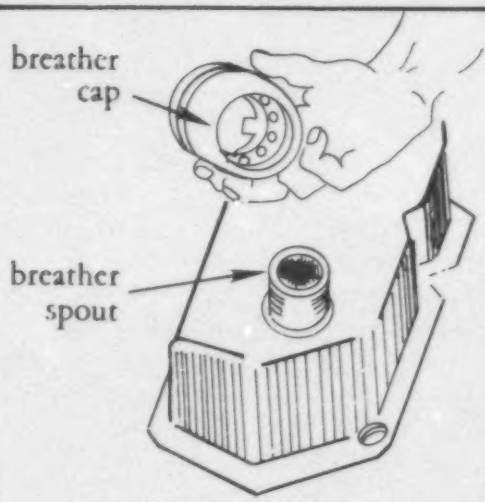
AIR CLEANER TYPES



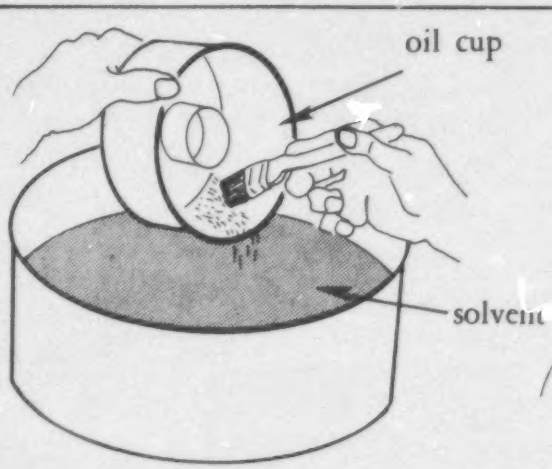
AIR CLEANERS & SERVICING



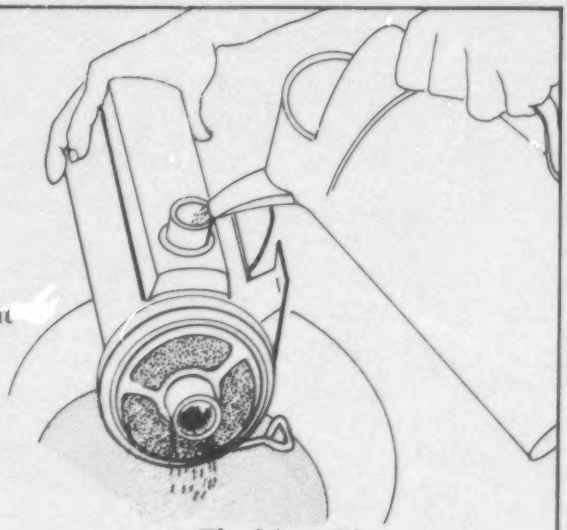
OIL-SOAKED CLEANER



OIL-SOAKED CRANKCASE BREATHER



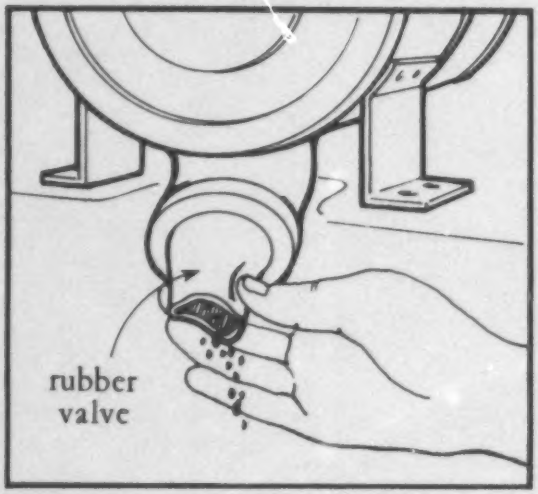
Cleaning Cup



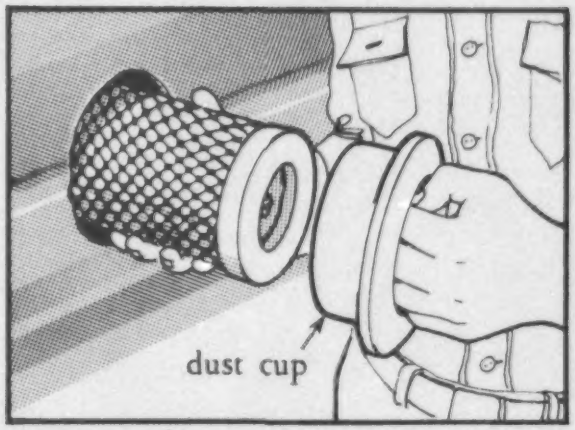
Flushing Element

CLEANING OIL-BATH CLEANER PARTS

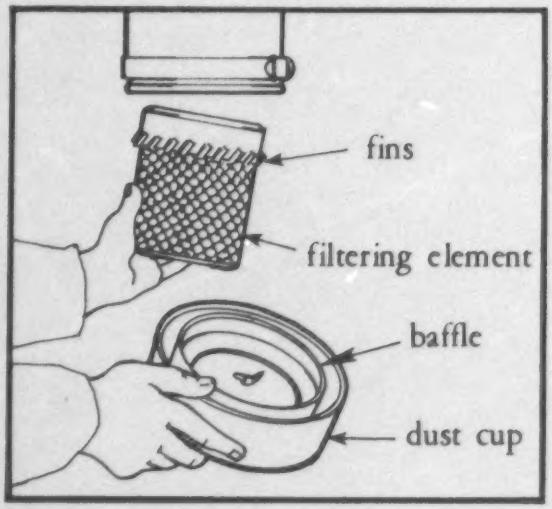
DRY TYPE AIR CLEANER



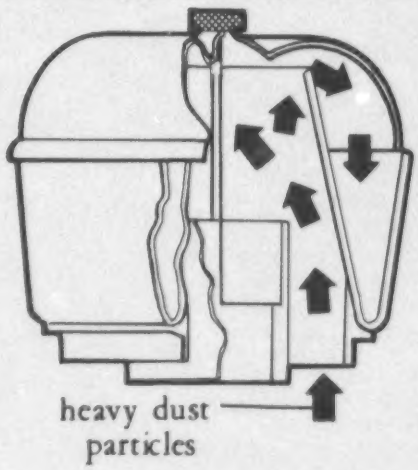
DUST UNLOADER
(rubber valve type)



REMOVING DUST CUP

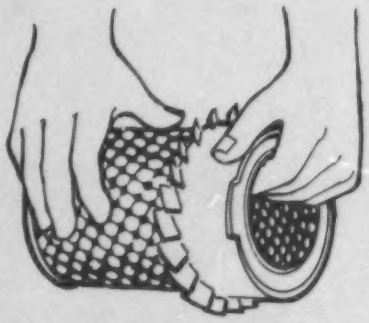


REMOVING FILTERING ELEMENT

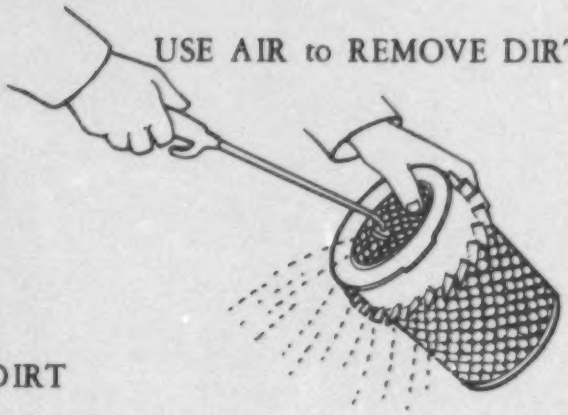


PRE-CLEANER

CLEANING THE DRY ELEMENT



TAP ELEMENT to LOOSEN DIRT



USE AIR to REMOVE DIRT

RINSE ELEMENT
with CLEAN WATER

WASH ELEMENT
in SOAPY WATER

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit B: Farm Truck and Tractor Maintenance

Topic 4: Lubrication

Suggested Procedures and Activities: During the class discussion the use of transparencies may be helpful in explaining the classification of oils and oil grades, types of lubricating systems, and the proper method of changing the crankcase oil. An exhibit of the different types of oils and greases may be used as teaching aids.

1. The Purposes of Lubricating a Truck or Tractor

The five major purposes for lubricating tractors are:

a. To lubricate moving parts. Oil and grease reduces friction to a minimum, by supplying a layer of oil between the moving parts. A proper layer of oil will actually separate wearing parts.

b. To assist in cooling moving parts. The pistons, wrist pins, main and connecting rod bearings depend upon the circulation of oil as a cooling agent. Oil removes heat from the moving parts of an engine and transfers it to cooler oil and metal surfaces. These surfaces transfer the heat outside the engine.

c. To act as a seal. Oil prevents the combustion gases from leaking past the piston rings which aids in the elimination of power loss. The seal may function as a cushion when metal parts are in contact with each other under great amounts of pressure. For example, on the power stroke of an engine, the oil film prevents metal-to-metal contact by absorbing the force created by the stroke.

d. To keep the moving parts clean. Soots and other contaminants are carried away in the oil to a filter where they are picked up and held. Other contaminants are held in suspension in the oil and eliminated when the crankcase is drained. In keeping the engine clean, oil acts as a carrier for corrosion and rust additives that are provided for these purposes.

e. To eliminate power loss caused by friction. Friction between metal moving parts is reduced if enough oil is present to provide viscous friction (friction between the molecules of oil).

Transparency No. 1

2. Classification and Grades of Oil and Types of Grease

The classification and grades of oil are based upon the oil properties. One of the most important properties is the body of the oil (viscosity). Oil's viscosity is determined by its ability to flow through a standard size opening at a given temperature.

a. The SAE (Society of American Engineers) Viscosity Classification System was adopted in 1926, to recommend motor oils to meet temperature requirements, design, and service affecting viscosity. Such properties as color and additives are not covered by this system.

Oils are classified into grades which are based upon the viscosity tests. SAE crankcase oils are classified in the following manner:

SAE Viscosity Numbers

SAE Grades	Multi-Grades
5W	
10W	5-W- 20
20W	10W - 30
20	20W - 40
30	
40	
50	

Multi-Grade oils do not become thin when they are heated. These oils also have the ability to resist thickening in low temperatures. However, all oils thicken to a degree when the temperature decreases. Oils thin when the temperature increases. Multi-Grade oils are also used in LP-Gas and diesel engines.

b. The API (American Petroleum Institute) system of classifying lubricating oil was developed on the basis of engine requirements under certain types of working conditions.

Summary of Current Equipment Manufacturer Recommendations

Application	API Performance Classification	Current Common Name
Gasoline Engine Passenger Car	SE	
Gasoline Engine Truck	CC SE	MIL-B
Diesel Engine	CB	Supplement - 1
Truck or Tractor	CC CD	MIL-B Series 3 (S-3)

c. Greases have two main ingredients, oil and soap-type thickening agencies. Greases range from very soft to very hard consistencies. The three most common types of soap thickener used in grease are:

Lime Soap Greases - These greases are used in a pressure gun to grease the chassis. They are not recommended on parts where the temperature exceeds 190° F. Lime soap greases are resistant to water.

Soda Soap Greases - These greases are made to withstand high temperatures, but they are not resistant to water. Soda soap greases are used on wheels and/or ball bearings.

Lithium Soap Greases - These greases are used extensively for greasing tractors. They are resistant to both heat and water, thus they are considered as multi-purpose greases. Some lithium soap greases contain additives with rust protection and pressure properties.

Transparencies Nos. 2 and 3

3. Types of Engine Lubricating Systems

The oil carried in the crankcase of a tractor engine lubricates the following parts by circulating and splashing the oil:

Main bearings and connecting rod bearings.

Cylinder walls, piston rings, piston pins, and pistons.

Camshaft bearings, cams, valve lifters, and valve guides.

Governor in most common tractors and the injection pump in some diesel tractors.

The common types of lubrication systems are:

a. Splash - This system was used on the earlier tractors. Oil was splashed to the working parts in the engine by cups, dippers, or troughs in the engine. This lubrication system is still used on one-cylinder engines.

b. Circulating -Splash - Oil is splashed to parts of the engine by the end of connecting rods as they revolve through the splash pan troughs. Oil is supplied to the troughs by an oil pump located in the crankcase. An oil mist caused by the ends of the connecting rods passing through the troughs lubricates the cylinder, piston assembly, and many other moving parts. Some channeling and piping to lubricate the bearings are found in the circulating-splash system.

c. Force -Feed - This system may be identified as a modified circulating-splash system, unless it is complete force feed. An oil pump picks up oil and forces it to the various parts of the engine. Oil passes from the main line to the main bearings, oil filter, and oil gauge. The secondary line lubricates the cam, idler gear, and timing gear. The third line, if present, lubricates the valve system. The connecting rods do not dip into troughs in this lubricating system. The relief valve maintains approximately 15 pounds of pressure, thus the oil is forced to most moving parts by pressure.

Transparency No. 4

The two types of pumps most commonly used are:

The external or gear pump is found on most tractors. It is driven by the camshaft.

The rotor or vane pump is usually driven by the crankshaft; therefore, it is found inside the engine.

Usually, if an oil pump is functioning properly, the oil pressure will show a normal reading. However, the reading may be normal when the oil is failing to circulate, if the engine is idling too slow.

4. Changing the Crankcase Oil

Lubricating oils wear out. They lose their lubricating qualities when the additives become depleted and the oil becomes dirty. Oils are contaminated with sludge, varnish, acid formations, fuel soot, and gasoline.

Oil is changed regularly and frequently to insure long engine life. A tractor starts and stops often, causing it to burn more oil than vehicles which travel long distances without stopping and starting frequently.

Crankcase oil should be drained while the oil is warm, so it is important to remove the oil immediately after stopping the tractor. More of the dirt, sludge, and other contaminants may be removed if they have not had a chance to settle out.

If the tractor is stored, new oil should be added at the beginning of the storage period. Fresh oil will eliminate sludge and dirt settling out in the crankcase.

During the winter (cold) months water will accumulate in the crankcase if the tractor is not allowed to run until a normal temperature is reached. Watery oil should be changed.

Most modern tractors are equipped with ventilation systems which dispose of the unburned fuels and water in the crankcase. The ventilation system reduces the formation of certain contaminants. This system takes air into the engine through the breather cap.

Factors that may influence the changing of engine oil are:

a. Length of running period between oil change.

b. Color of the oil. The oil may be dark and still have body and film-forming ability.

c. Oil contains water, sludge, and other contaminants.

d. Long idle periods for the tractor.

e. Running the tractor on many short trips during cold months.

f. Using tractor on dusty or dirty types of jobs.

g. Metal and other abrasive material collected in the crankcase.

Transparency No. 5

Crankcase oil is changed by removing the oil drain plug from the oil pan. The plug is replaced after the hot oil is completely removed. Follow the recommendations of the manufacturer regarding the type of oil to use.

Transparencies Nos. 6 and 7

5. Changing the Oil Filter

a. The purpose of the oil filter is to remove the impurities from the oil such as abrasive and other foreign materials. Most tractors are equipped with oil filters.

b. The two most common types of filters found on tractors are the surface and depth.

Surface Filters - These filters strain the particles of dirt as the oil passes through a straight line path through the holes. The holes are smaller than the dirt particles; therefore, as the particles hit the surface, they fall into the filter reservoir. These filters are made of either wire mesh, stacked metal, or paper disks.

Depth Filters - The depth filters are absorbent or adsorbent. The absorbent filters will trap porous materials, soak up water, and soak up impurities. The cotton, wood, wool, or paper materials reacts like a sponge that takes in water. The adsorbent filters are chemically treated so they attract and remove impurities.

c. Servicing most filter systems is accomplished by replacing the removable cartridge. Some makes of tractors have filter elements contained in a removable housing. The housing and mounting base in this type of filter should be cleaned with a solvent and dried with compressed air. If the relief valve is removable it should be cleaned and dried.

Metal filters (edge-type) should be soaked about a day in lye water if the filter has a varnish-like substance on it. In most cases a metal filter can be cleaned with solvent and a brush.

When servicing a filter, new gaskets and rings should be used. It is usually recommended that the filter be changed at the same time the crankcase oil is changed. The engine should be allowed to run until adequate oil pressure registers on the gauge, then checked for leaks.

6. Lubrication of Tractor Transmission and PTO Drives

Transparency No. 8

Transmission care is equally as important as lubricating other parts of the tractor. The lubricant in the gear case is splashed, pumped, or splashed and pumped to all working parts.

Gear lubricants undergo the same changes as engine lubricants. Oxidation and thickening may take place and the additives may become depleted.

The contaminants found in a transmission are: fine dust, moisture, and metal particles.

Transmission lubricant should be changed only when the oil is warm. If the transmission is to be flushed after it is drained, kerosene or diesel oil should be used. Flushing is accomplished by filling the gear case with the thin lubricant and then driving the tractor for several minutes before draining and refilling with a new lubricant. Some transmissions have more than one drain plug. The operator's manual explains the type of lubricant that should be used.

7. Important Things to Remember About Greasing the Truck or Tractor

The operator's manual is used to determine when and how to lubricate (grease) the tractor. Tractors that work under moist or dusty conditions need lubricating more frequently than tractors working in ideal conditions.

It is very important to use the right type and right amount of grease. Some working parts (steering system) are enclosed in a rubber container that may be damaged if too much grease is added at one time.

All grease fittings must be wiped clean before applying grease with the grease gun. Grease must be free of impurities. Abrasive dust particles can destroy a bearing in a very short time.

References:

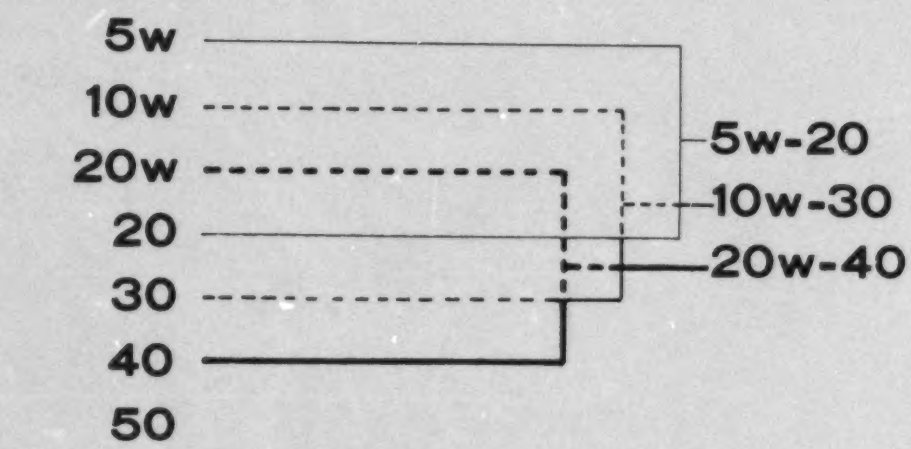
"Farm Tractors - Basic Principles, Operation and Maintenance", Engineering Bulletin, FT-53, American Oil Co., Chicago, IL, 1968

"Fundamentals of Service Engines", Deere and Co., Moline, IL, 1972

Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, IL, 1967.

Promersberger, William J. and others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971

CLASSIFICATION OF OILS



API CLASSIFICATION GASOLINE

se - passenger autos

se or cc - trucks

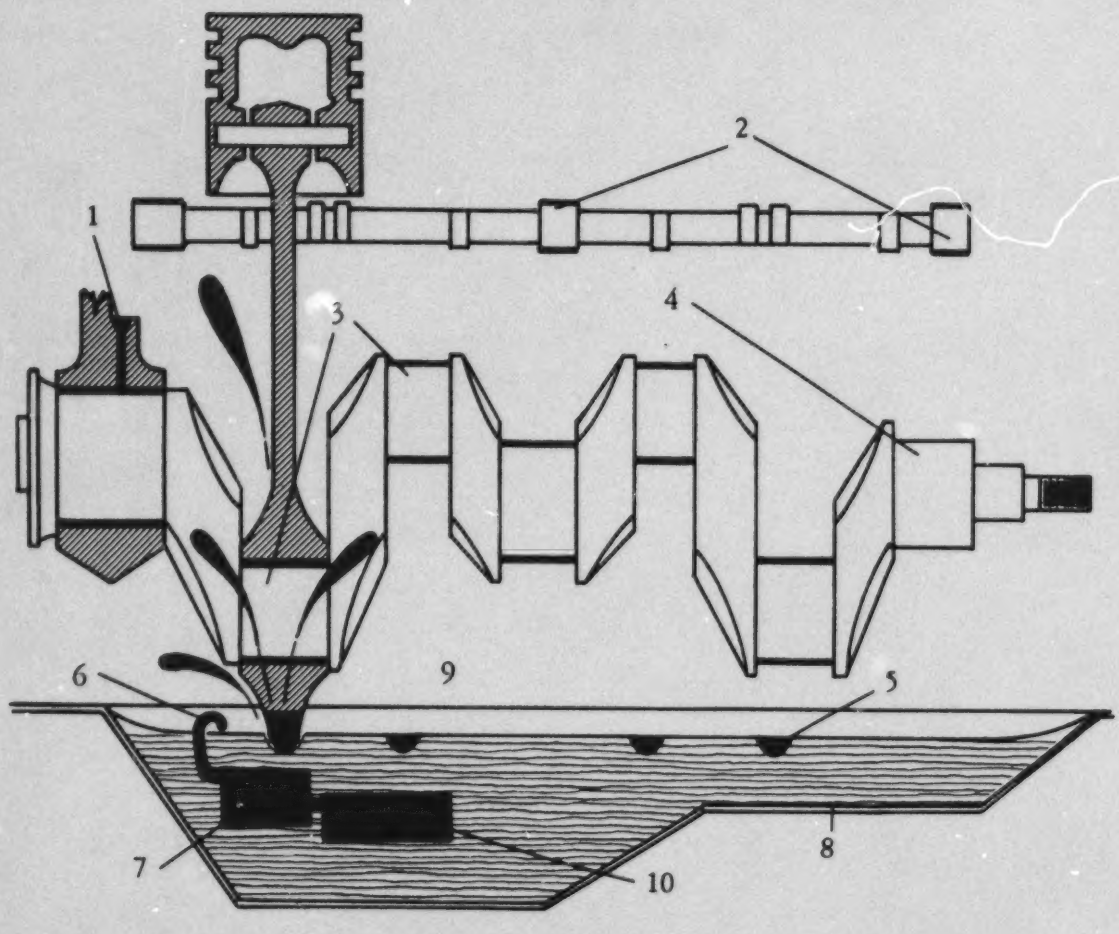
DIESEL

cb - normal service

cc - severe service

cd - very severe service

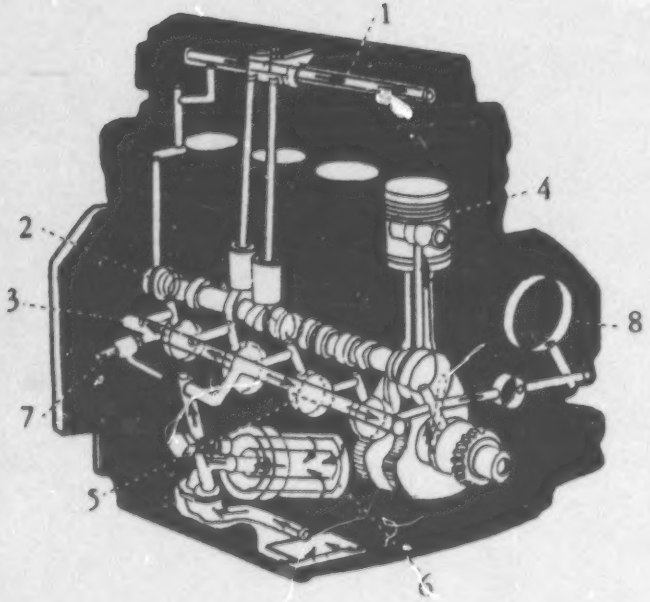
LUBRICATION SYSTEM



CIRCULATORY SPLASH

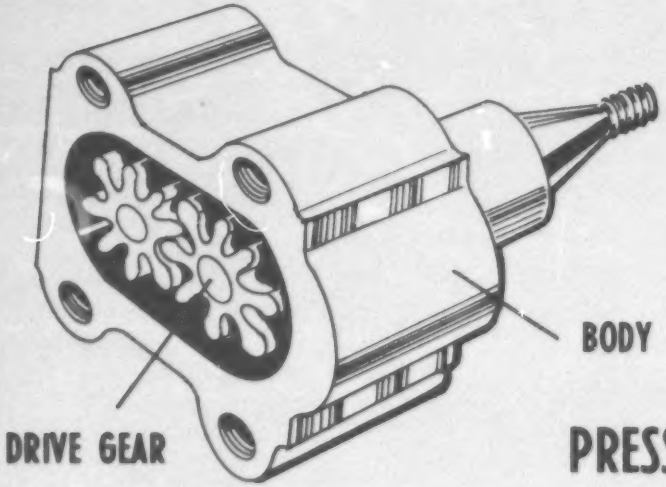
1. OIL TROUGH
2. CAMSHAFT BEARINGS
3. ROD BEARINGS
4. MAIN BEARINGS
5. SPLASH TROUGHS
6. SPLASH PAN SUPPLY TUBE
7. OIL PUMP
8. OIL PAN
9. OIL DIPPER
10. OIL STRAINER

LUBRICATING SYSTEM

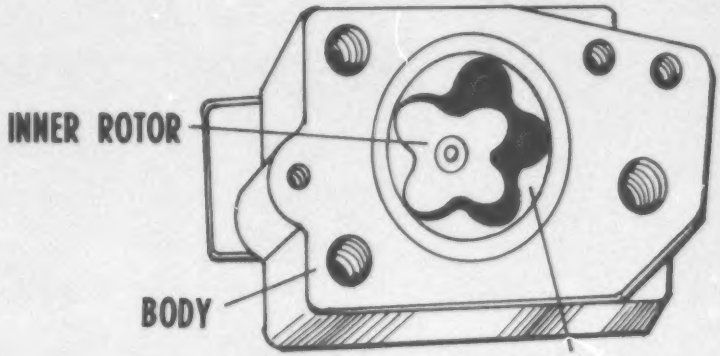


FORCE FEED

1. TAPPET SHAFT
2. CAMSHAFT BEARINGS
3. MAIN OIL GALLERY
4. PISTON PIN BEARINGS
5. MAIN BEARINGS
6. OIL PUMP AND FILTER ASSEMBLIES
7. OIL PRESSURE SCREW
8. VENTILATOR PUMP

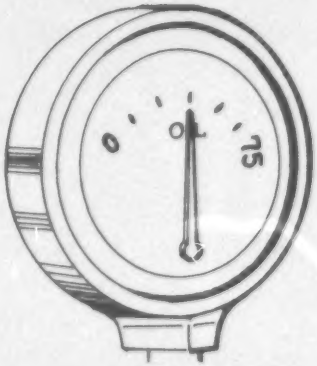


EXTERNAL PUMP



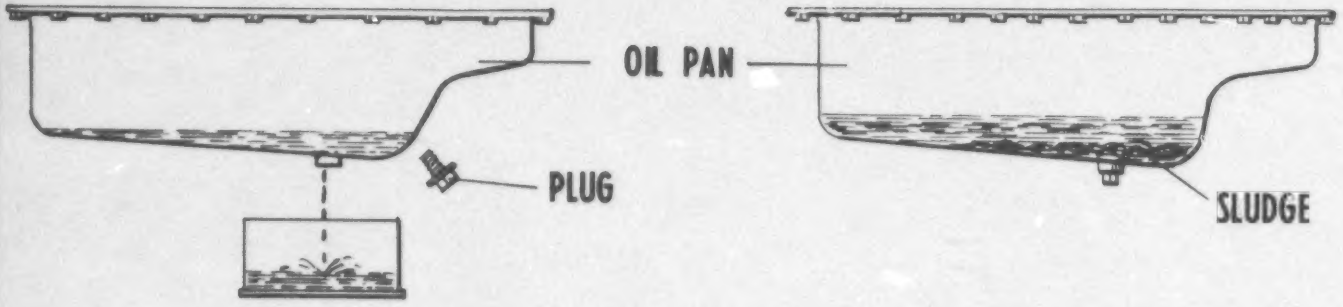
ROTOR PUMP

PRESSURE GAUGE

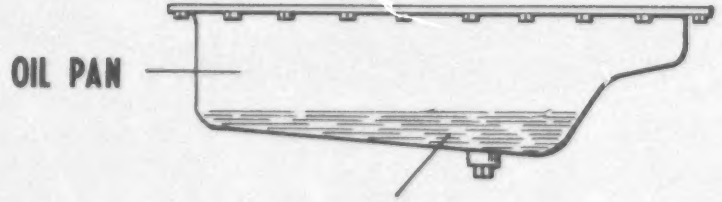


OIL PUMPS AND PRESSURE GAUGE

DRAINING OIL AND CHANGING FILTER

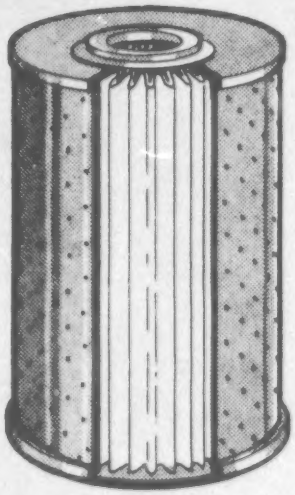


CHECKING OIL LEVEL

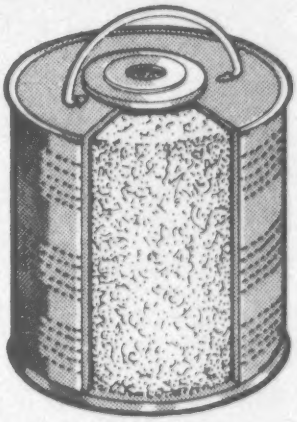


OIL FREE OF SLUDGE

TYPES OF OIL FILTERS

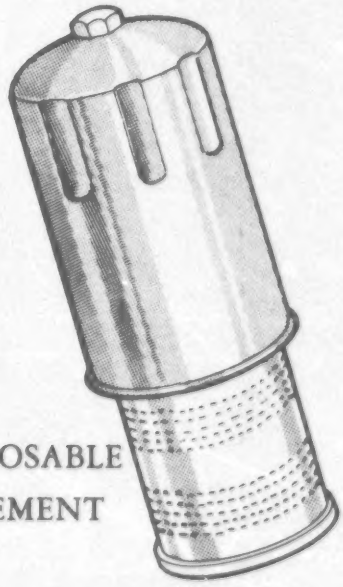


SURFACE FILTER



DEPTH FILTER

DISPOSABLE FILTER

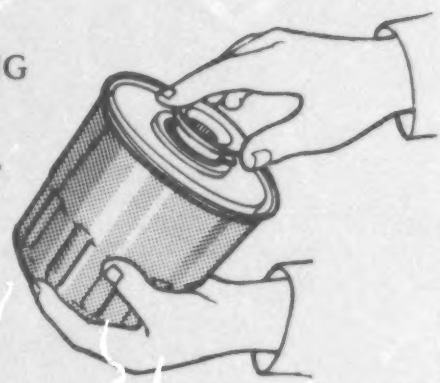


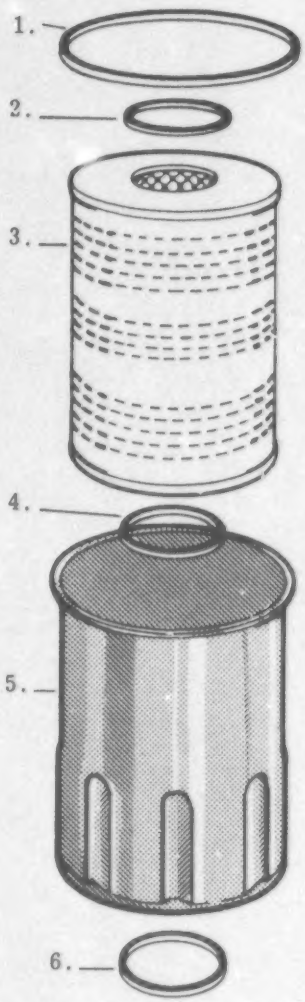
DISPOSABLE
ELEMENT

SERVICING OIL FILTER

CLEANING
FILTER
HOUSING

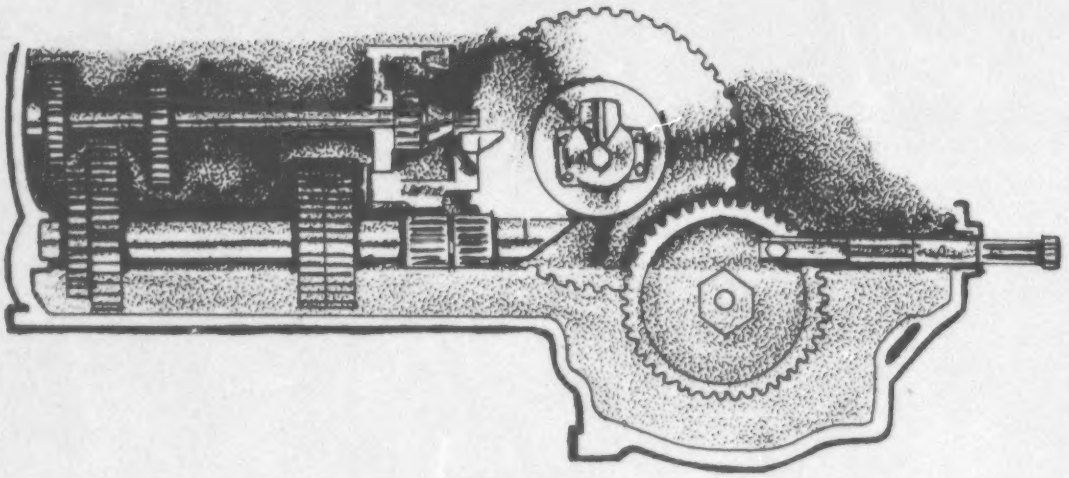
REPLACING
BYPASS
ELEMENT



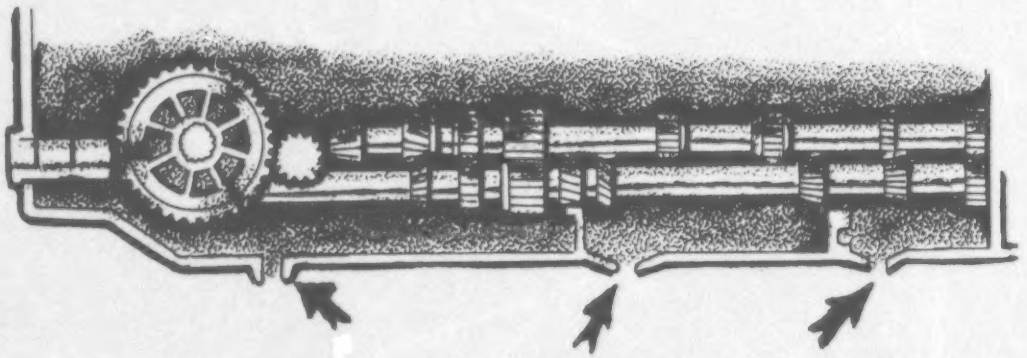


1. HOUSING GASKET
2. GASKET
3. FILTER ELEMENT
4. GASKET
5. FILTER HOUSING
6. GASKET

TRANSMISSION LUBRICATION



LUBRICATION LEVEL
ON SINGLE COMPARTMENT TYPE TRACTOR



THREE COMPARTMENTS FOR LUBRICATION
OF TRANSMISSIONS & PTO DRIVE

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 1: Cooling

Suggested Procedure and Activities: An exhibit made up of a water pump, thermostat, radiator cap, cooling system hoses, drive belts, and corrosion inhibitors may be helpful during the topic discussion.

1. Purpose of an Engine Cooling System

The functions of the cooling system are to remove excess heat that is generated by the combustion of fuel in the combustion chamber and to regulate the temperature of the engine. It is estimated that about 40 percent of the heat is transmitted through the cylinder walls and removed by the cooling system.

Excessive heat in an engine may cause engine problems such as oil breakdown, formation of varnish, sticking and burned valves, engine knock, and a cracked engine head or block.

Gasoline engines operate efficiently when the temperature is 165 to 185 degrees F. Diesel engines operate at 180 degrees F. and above. Engines that operate on heavy type fuels may perform more efficiently at about 190 degrees F.

The cooling system does not eliminate all of the heat that is generated by the engine. About 30 percent of the heat in the engine is converted into power to move the tractor. Another 30 percent passes through the exhaust and is wasted. Thus, about 40 percent is removed by the cooling system.

2. Types of Liquid Cooling Systems on Trucks and Tractors

Transparencies Nos. 1a, 1b, and 2

a. Forced Circulation System - Water or other types of coolants are forced to circulate within the cooling system by means of a water pump. The most commonly used cooling liquid for farm tractors is water or a mixture of water and antifreeze.

Water is forced from the bottom of the radiator by the water pump to jacket spaces around the cylinders and through holes around the cylinder head and then through a hose to the top of the radiator.

The water passes through radiator tubes that are surrounded by air passages and fins where most of the heat is removed. As the water enters the bottom of the radiator, it flows through a rubber tube into the water pump to repeat the cycle.

The flow of water in the cooling system is controlled by a thermostat which is located at the point where the heated water leaves the engine. The thermostat opens and allows water to circulate in the cooling system when the coolant reaches the proper temperature. If the thermostat is closed on a cold engine, the water circulates through the engine block only.

The radiator pressure cap serves a very important function in the pressure type forced circulation system. The engine can operate at a higher temperature without losing the water by evaporation or boiling it out. The cap also permits atmospheric air to enter the radiator as the system cools down. Most caps are built with a spring-loaded valve that functions under a 6 to 7 pound pressure.

Most tractors are equipped with a suction-type fan; that is, air is pulled through the radiator and pushed over the engine. Usually the fan is located about 2 1/2 inches from the radiator core. Slow moving farm machinery and machinery that might pull an excessive amount of harmful materials through the radiator are equipped with a blower type fan. The air is pulled over the engine and pushed through the radiator.

b. Thermosiphon System - This system is made up of all cooling parts of the forced - circulation system except the water pump and thermostat. The circulation of water in this cooling system is caused by its expanding and becoming lighter as it is heated. The hot water works from the water jackets to the radiator where it contracts due to cooling. Contracting causes the water to become heavier and descend in the cooling system to the engine. The rate of circulation depends upon the heat of the engine.

3. Servicing the Parts of the Cooling System

The entire cooling system (radiator, hoses, water pump, cylinder block, and drain valves) may be checked for leaks by connecting a radiator pressure tester to the filler cap opening and forcing air into the radiator. The radiator cap may also be tested by using the pressure tester connected to the cap.

Transparencies Nos. 3 and 4

a. The radiator should be inspected for the following conditions: bent or damaged fins, dents on the frame and tanks, fractured seams, cracked tubes, clogged or bent overflow tube and deteriorated rubber cushioned

washers.

The radiator may be tested for leaks by plugging the outlet pipe and overflow tube and then forcing 7 to 10 pounds of compression into the radiator as it is submerged in water. Bubbles will identify the location of leaks. Leak surfaces should be cleaned and soldered. Fins should be straightened.

b. A defective radiator cap should be replaced. The pressure and vacuum valves should be checked at the same time the radiator is checked.

c. The fan should be checked for bent blades and the closeness of the blades to the radiator core. If the blades are not properly adjusted, inefficient cooling may result and the fan may be out of balance.

d. Fan belts should be checked frequently for the proper tension and wear. If the belt is too tight, bearing wear will be excessive. A loose fan belt may cause engine overheating and excessive belt wear. Belt tension may be set by using a torque wrench.

e. The water pump is the "center" of the forced circulation system. Most modern tractor water pumps need little lubrication care. The bearings are sealed and self-lubricated. They should be checked for leaks in the housing, damaged seals, and broken impeller vanes.

f. The engine should be operated only when the thermostat is in good working condition. A corroded or damaged thermostat should be replaced. A thermostat may be checked by submerging it in water around 20 to 24 degrees above the thermostat temperature. It should be open at this temperature. If it has a damaged bellow, the liquid on the inside may be lost, causing the thermostat valve to be stuck open. The thermostat on a tractor should be checked annually.

g. Cooling system hoses can be checked by squeezing the hose to see if it is hard and brittle or soft and swollen. A loose or cracked hose may admit air in the cooling system, causing rust to accumulate faster than normal. Loose and cracked hoses may permit the coolant to escape. Rubber particles from an old deteriorated hose may cause the radiator tubes to clog.

Radiator hoses are either the molded type or the flexible accordian type. Some tractors are equipped with hoses that have a spiral wire inside to prevent collapse. All hoses should be replaced with the type that is recommended for the cooling system. A hose fitting should be treated with a sealer before the hose is clamped on it.

4. Keeping the Cooling System Filled with the Proper Coolant

The cooling system of a tractor should be drained two times per year- spring and fall. The steps are as follows:

a. Drain and flush the cooling system with clean, soft water. Flush the system with a cleansing agent if it is corroded or contains rust.

b. Check for leaks and tighten all conections after flushing the radiator.

c. If the cooling system is drained at the end of the winter season, fill it with soft water and add a rust inhibitor. If the sytem is drained in the fall of the year, add a mixture of antifreeze and water (ethylene glycol base) to prevent the cooling system from freezing. The engine should run a few minutes in order to circulate and mix the coolants. Water absorbs heat more rapidly than antifreezes; therefore, it should be used as a coolant, except during the winter months or the months that have freezing temperatures. Water may be used the entire year as a coolant if the cooling system is drained each time after work during the freeze season.

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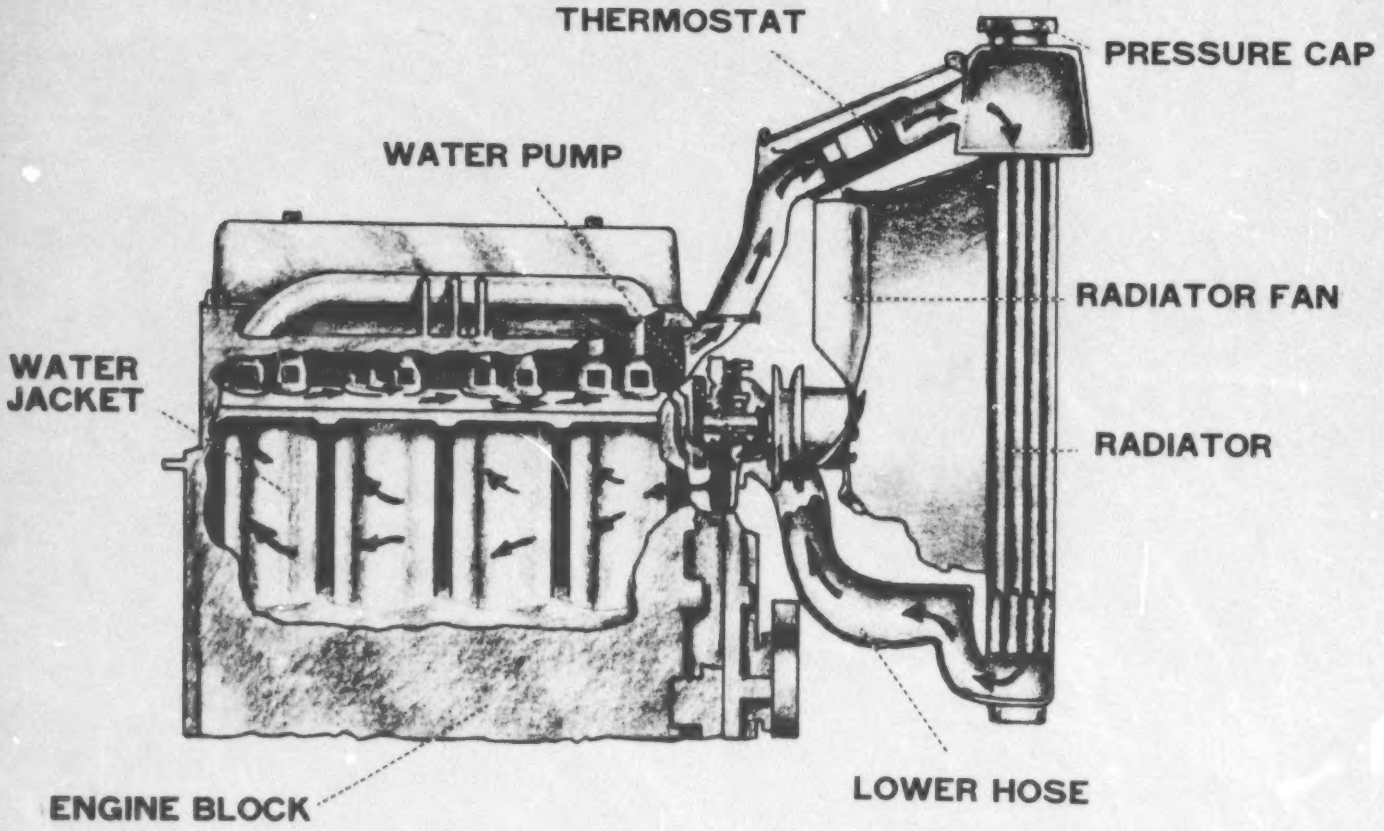
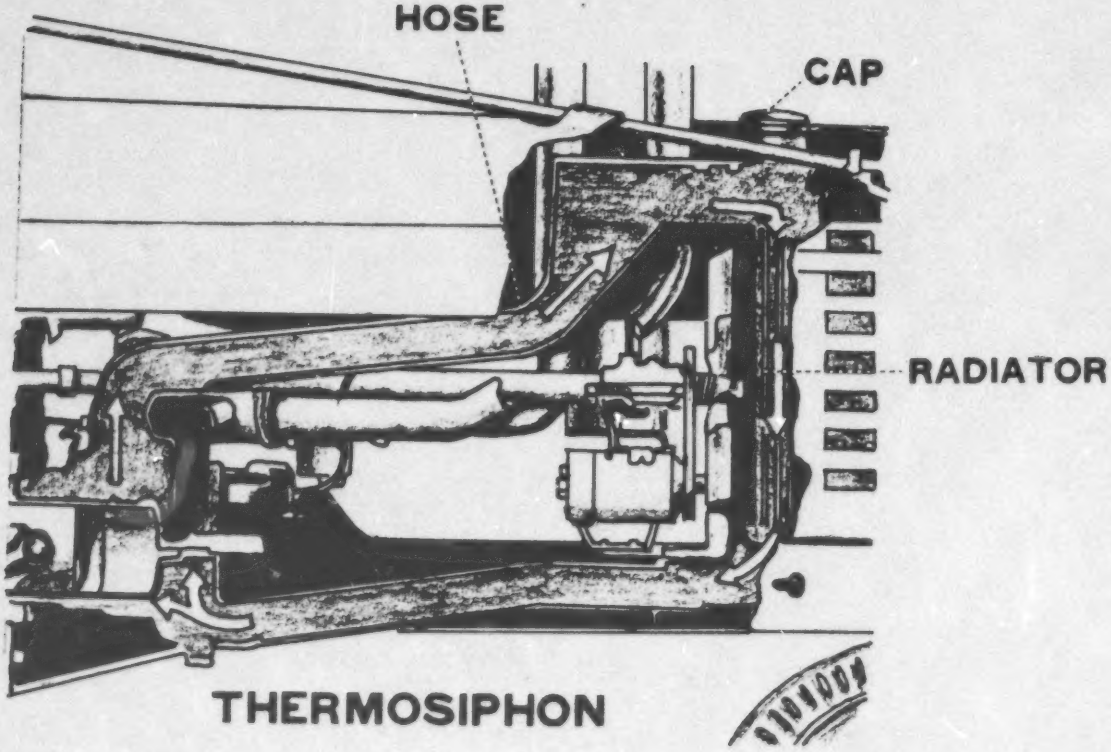
"Fundamentals of Service Engines", Deere and Company, Moline, IL, 1972

COOLING SYSTEMS



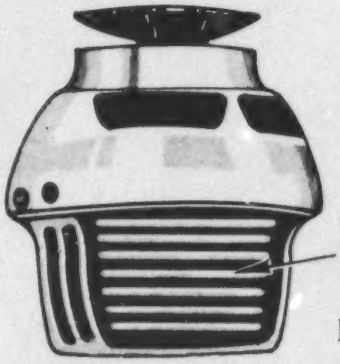
FORCED-CIRCULATION

COOLING SYSTEM

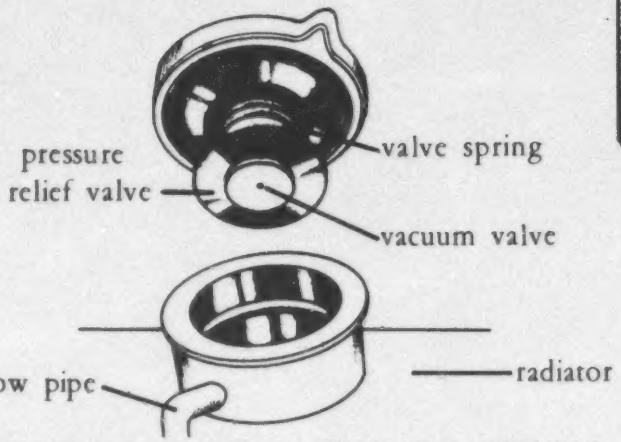


THERMOSIPHON

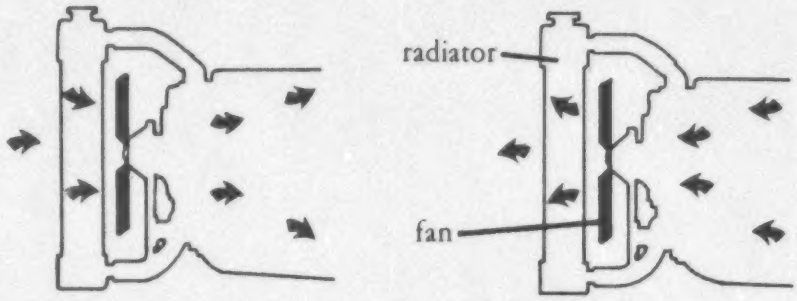
COOLING SYSTEM



BELLOWS TYPE THERMOSTAT

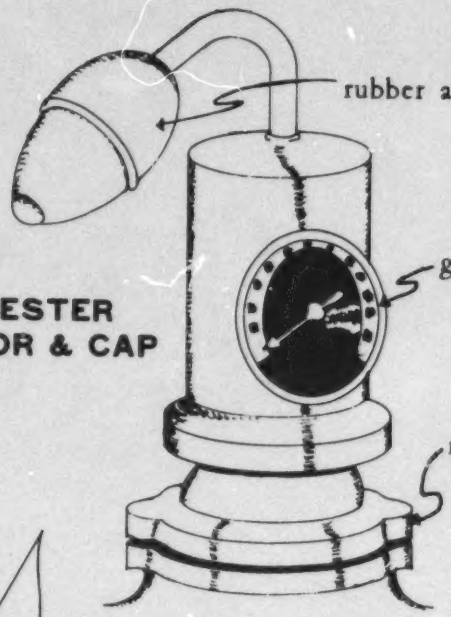


RADIATOR CAP & FILLER NECK

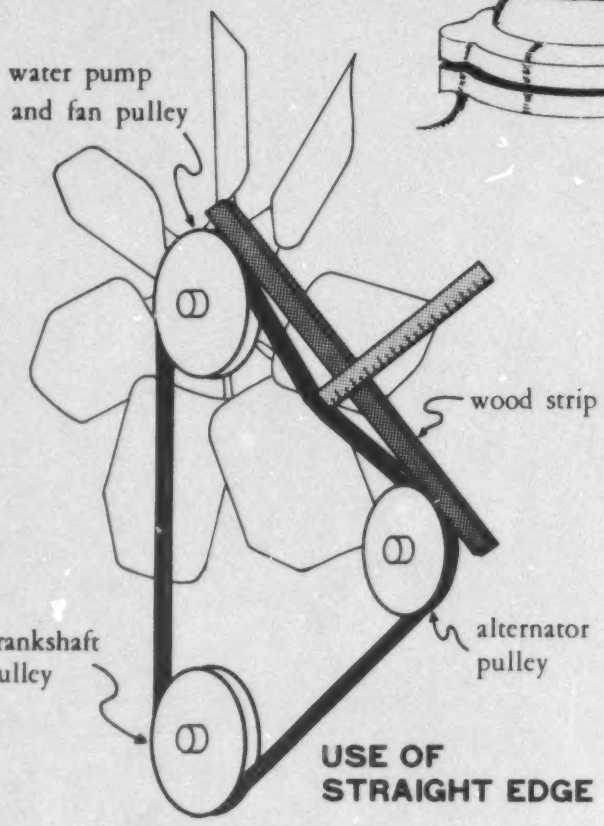


SUCTION TYPE FAN BLOWER TYPE FAN

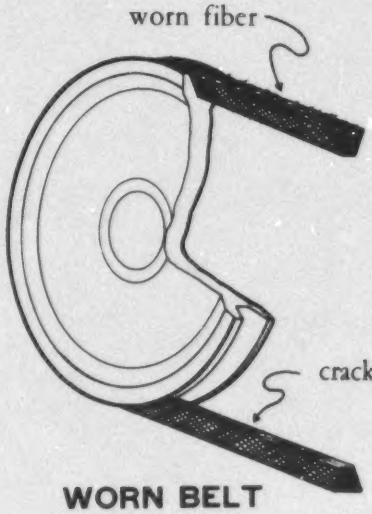
CHECKING AND ADJUSTING PARTS OF COOLING SYSTEM



PRESSURE TESTER FOR RADIATOR & CAP

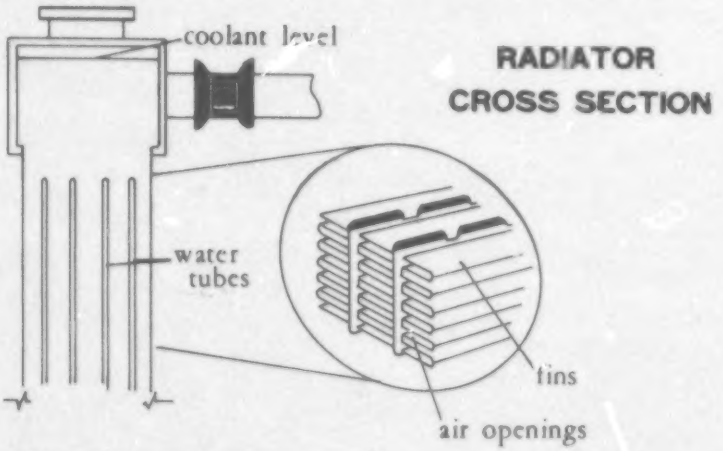


USE OF STRAIGHT EDGE

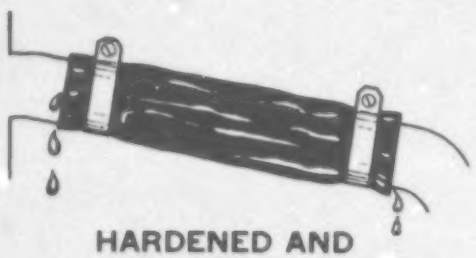


WORN BELT

COOLING SYSTEM

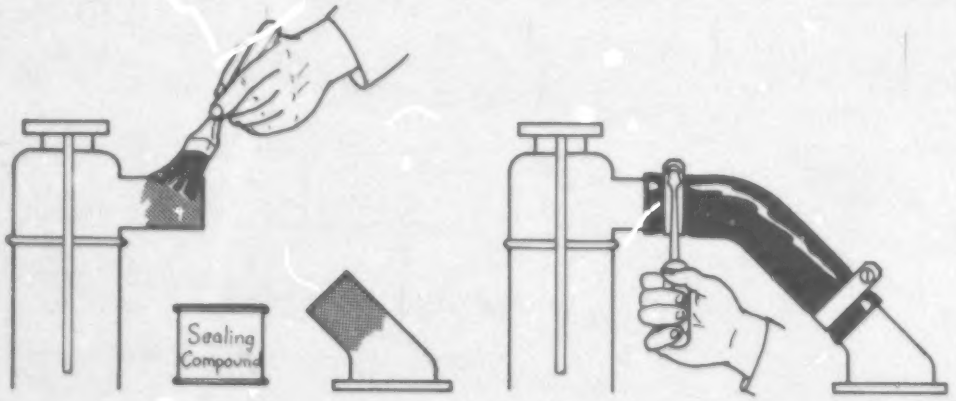


RADIATOR
CROSS SECTION



HARDENED AND
CRACKED HOSE

SOFT AND
SWOLLEN HOSE



NEW HOSE INSTALLATION

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 2: Fuel

Suggested Procedure and Activities: A carburetor and a fuel pump may be used as teaching aids during the class discussion.

1. Introduction - Kinds of Fuels Used in Tractors

There are three major fuelsused in modern tractors. The type or kind of fuel used depends on the type of engine used for a specific job. For example, light jobs are performed by using lightweight tractors. These tractors are designed to use gasoline as a fuel. Heavy work is usually done by a diesel fuel burning tractor. In some regions LP gas is used as a tractor fuel. A description of these major fuels is as follows:

a. Gasoline has the highest volatility rating of any liquid fuel; that is, it will change to vapor more readily than distillate, kerosene, or other heavy liquid fuels. Gasoline changes from a liquid to a vapor at a low temperature (105 degrees F). It is convenient to use because it can start an engine easily, has a high power potential, and burns cleanly.

b. Diesel fuel is less expensive than gasoline. It is a higher energy fuel than gasoline or LP gas. It is not a volatile fuel. Diesel will usually give more power than lighter fuels in the same size engine. It is not considered a clean burning fuel.

c. LP gas is also less expensive than gasoline. In fact, butane, propane, or a mixture of both is a more economical fuel than gasoline. These liquid gases are considered clean burning fuels, and they vaporize very easily. LP gases are used in large engines.

2. Function of the Gasoline Fuel System

Transparency No. 1

The gasoline fuel system is made up of four main parts: the fuel tank, fuel pump, sediment bowl, and carburetor. The functions of fuel systems parts are:

a. Fuel Tanks - Most tractors are equipped with either one or two fuel tanks.

The tank or tanks may be equipped as follows: fill cap with air vent which permits air to replace the fuel, fuel strainer, and fuel tank valve. Some tractor fuel tanks have a sediment bowl at the tank outlet or a strainer in the fuel line.

Tractors that do not have the tank located above the level of the carburetor are equipped with a fuel pump. The pump is usually operated by a camshaft. The fuel pump lever (cam operated) returns the pump diaphragm on the suction stroke, thus pulling in fuel. Constant pressure is maintained in the pump.

b. Sediment Bowl - Tractor fuel systems are equipped with a sediment bowl and fuel strainer. These parts protect the carburetor jets against dust particles and residue that may be in the fuel. Some fuel systems have two strainers; one is located at the sediment bowl, and the second is located at the carburetor.

c. Carburetor - The major purpose of a carburetor is to provide a fuel air mixture for the engine cylinders. A float bowl equipped with a needle valve maintains a constant level of liquid fuel that either flows to it by gravity or is pumped from the tank to the carburetor by a fuel pump.

At a constricted section of the manifold (venturi) gasoline is introduced into the air stream, where it is picked up and atomized. The throttle valve is located above the jet nozzle and venturi tube. This valve controls the amount of the mixture of air and gasoline reaching the engine. When there is a need for extra power, the throttle valve is opened by the governor, permitting the faster moving air to make a richer mixture. As soon as the demand for extra power is over, the richness of the mixture is reduced automatically by the governor. A rich mixture is 9 to 1 (nine pounds of air to one pound of fuel). A lean mixture is about 17 to 1. An idling mixture is about 12 to 1. The choke of a carburetor reduces the amount of air, causing the mixture to become very rich, 2 to 1, for starting purposes.

3. Function of the Fuel Supply for Diesel Engines

Transparency No. 2

There are five major fuel system parts found on diesel engines. They are:

a. Fuel Tank - The function of the tank is the same on both diesel and gasoline systems. The tank is to store fuel. Most tanks have only a fuel tube leading from the tank to the transfer pump.

b. Fuel Pump - This pump takes the fuel from the tank and pushes it through the fuel filters to the injection pump.

c. Fuel Filters - The fuel filters are one of the most important parts of the fuel system. The auxiliary and final stage filters are equipped with air bleed plugs and drain valves. The filters help clean the fuel by removing the dirt and other foreign materials before it can enter the injection pump.

d. Injection Pump - This pump puts the oil under pressure and delivers it to each injection nozzle, where it is atomized and sprayed into the cylinder. Combustion takes place at this point.

A full cylinder of air is taken in on the intake stroke of a 4-cycle diesel engine. The air is blown into the cylinder on a 2-cycle engine.

4. Function of the Fuel Supply System for LP Gas Engines

The two liquified petroleum gases, propane and butane, remain a liquid as long as they are under proper pressure. Butane is sometimes blended with gasoline for winter use. Propane is also mixed with butane for winter use. Both of these fuels are cheaper to use than gasoline, and they are considered the cleanest fuels for tractors. They leave less carbon deposits than gasoline and diesel engine fuels.

Transparency No. 2

The major parts of a liquid withdrawal LP gas fuel system are:

a. Pressurized Fuel Tank - The strong heavy tank is mounted on the tractor. The tank is never filled to capacity with liquid fuel due to the space needed for vapor in the tank. The level to fill the tank is shown by a dial gauge.

b. Fuel Filter - The liquid fuel passes through a fuel filter or strainer on its way to the converter. Most fuel system have filter system that are equipped with a solenoid which permits fuel flow when the engine ignition switch is on.

c. Converter - As the liquid fuel enters the converter, it is changed to vapor. In the liquid withdrawal system the liquid fuel is changed to vapor in the converter by warming and dropping the pressure of the vapor. Hot water is circulated through a coil in the converter to change the high-pressure liquid to low-pressure gas.

d. Carburetor - The LP gas carburetor is similar to a gasoline engine

carburetor; it has a choke, throttle, and economizer. Air is mixed with fuel vapor in a ratio suitable for engine performance and supplied to the engine cylinders. Most LP gas carburetors do not have a fuel supply system or venturi.

5. Maintaining the Fuel Supply System

In order for a fuel supply system to give good performance, it is necessary that all parts of the system remain in proper working condition. Many tractors operate several seasons and even years without mechanical problems caused by the lack of care of the fuel system.

Transparency No. 3

a. Maintenance of the Fuel Tank - Even though the fuel tank is a very important part of the fuel system, it does not require the amount of time and attention that is necessary to maintain the carburetor and fuel pump. If the fuel tank is filled at the close of a day's operation, there will be less opportunity for the tank to collect moisture.

Maintenance jobs on the fuel tank are as follows:

Open the drain plug periodically to remove water and sediment that may have collected in the tank. The inside may be flushed with hot water and soap. The outside should be washed with hot water and soap. The soap should be rinsed from all surfaces.

If the tank is to be checked for leaks, it should be removed from the tractor. The two methods for checking leaks are:

Wet Method - Place the tank on a flat surface so that the entire surface may be seen and fill it with water. Be sure that the entire outer surface is dry and clean. Force about 3 pounds of air pressure against the water and check for leaks.

Air Pressure Method - Attach an air hose to the fuel outlet after plugging the filler inlet. Submerge the tank in water and force about three pounds of air into it. Mark each place on the tank where air bubbles appear.

Leak holes may be soldered without the danger of an explosion if the soldering iron is not red hot. If the holes are to be welded, an experienced welder should perform the job.

The tank cap should be replaced if it is damaged or worn. The cap gasket should be checked every few months.

Tank fuel lines should be checked for loose connections, damaged fittings, dents, and kinks. Fuel will leak from loose or damaged fittings.

Transparency No. 4

b. Maintenance of the Fuel Pump - Fuel pumps may be tested by either using a pump analyzer or a visual test. If the visual test is used, the pump - to - filter line is disconnected at the filter, the tractor throttle is set in a nonstart position, and, as the engine is turned over, fuel spurts from the line; that is, if the pump is functioning properly. It may be necessary to disassemble the pump in order to check the diaphragm for leaks, check the gasket for cracks, and check pump spring tension. All worn parts should be replaced.

Transparency No. 4

c. Fuel Filters - If the engine is equipped with a fuel filter to stop water and/or foreign objects before reaching the fuel pump, it should be checked periodically and drained. If the filter is equipped with a screen and sediment bowl, they should be removed and cleaned periodically. Any part should be replaced if it is damaged or cannot be cleaned.

Transparencies Nos. 5, 6a, and 6b

d. Carburetor - The carburetor is checked and adjusted according to the type of work performed by the engine and the length of time the engine has been in operation. If the carburetor functions smoothly, it should be checked and adjusted each 250 hours.

The carburetor should always be serviced after an engine overhaul or tune-up. To properly service the carburetor, use all the new parts that are found in the service repair kit. The following maintenance steps should be observed when servicing a carburetor:

Clean all metal parts with a cleaning solution and rinse in a solvent.

Do not use small bits or wires to clean the jets or orifices.

Adjust the needles properly. The needle seat may be damaged if they are seated too tight.

Test the metal float for leaks and check its height according to manual recommendations.

Drain the carburetor if the engine is to be idle for several months.

Tighten all screws, especially those which hold the throttle dish in

place. These screws can be drawn into the combustion chamber.

The carburetor must be maintained in proper adjustment for smooth economical operation of the engine. The three basic adjustments on most carburetors are idle speed, idle, and full-load. The ignition timing and speed adjustment are affected by the carburetor adjustments; therefore, if one is changed, the other should be checked. The engine should be warm before making any carburetor adjustments. The methods of making two simple adjustments are:

Idle Fuel Mixture - The idle fuel screw is turned in until the engine begins to operate roughly; then it is turned out until the engine idles smoothly.

Full-Load Fuel Mixture - Adjust the full load fuel needle while the engine is operating under full load. The load screw is turned in until the engine loses power; then it is backed out until the engine runs smoothly. The fuel mixture to the engine should be adjusted while it is stationary.

6. Special Maintenance Practices for Different Types of Fuel Systems

a. LP Gas - LP gas fuel tanks should not be serviced except when it is necessary to replace a valve or gauge. The gauges and valves should never be serviced except to remove them from the tank and install them. When replacing a valve or gauge, the fuel should be removed to relieve the pressure.

When servicing fuel strainers, the engine should be cold. The withdrawal valves should be closed and the strainer and lines freed of gas.

LP gas carburetors are different from gasoline carburetors in that they have no float or float tank, because the fuel enters the carburetor as a vapor instead of a liquid fuel as in gasoline or diesel engine fuel. There is no pump to maintain, but this system has a converter that must be properly cared for, especially if the coolant freezes in it.

Transparency No. 6b

b. Diesel Fuel System - A diesel engine is usually equipped with several fuel filters. Many engines have primary and secondary filters to protect the fuel injection system and engine from the finest particles of abrasive sediment and dirt. If a diesel engine begins to miss, the first place to check is the fuel filtering system. The diesel system does not have a carburetor. It is equipped with a fuel pump and filter system similar to those of gasoline engines.

The metering valve, governing mechanism, and injection system should be adjusted by a skilled mechanic.

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Promersberger, William J. and others, Modern Farm Power, Prentice-Hall Inc., Englewood Cliffs, NJ, 1971

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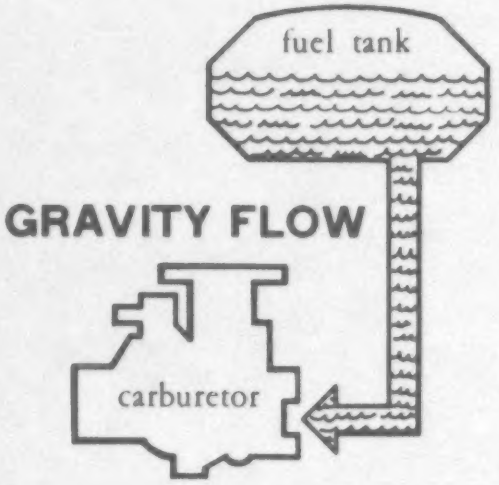
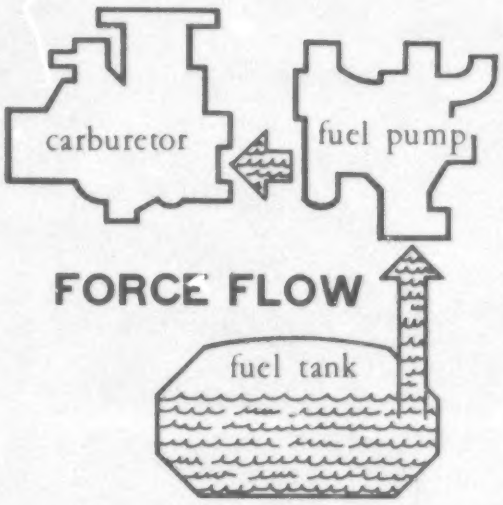
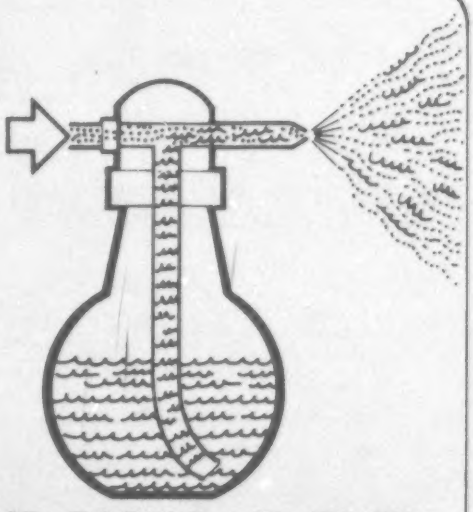
"Fundamentals of Service Engines", Deere and Company, Moline, IL, 1972

"Fundamentals of Service - Fuels, Lubricants, and Coolants", Deere and Company, Moline, IL, 1974

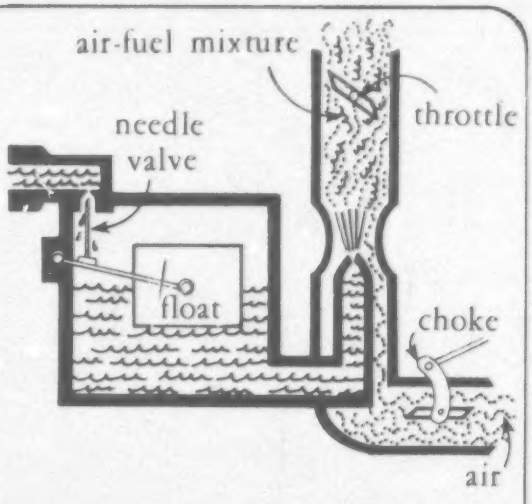
FUEL SYSTEM





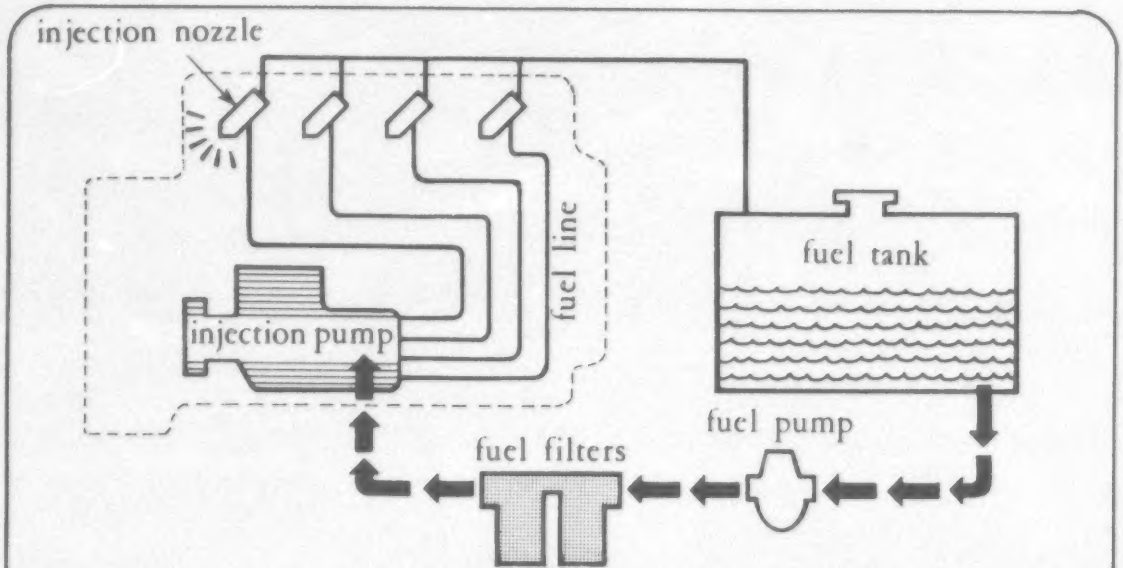


AIR PICKS UP FUEL & FORMS MIXTURE

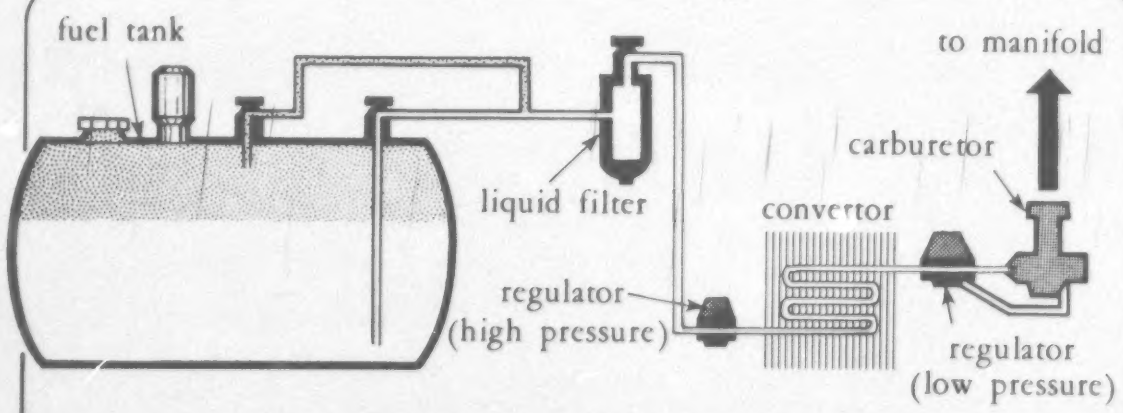


MIXING AIR & FUEL

FUEL SYSTEM

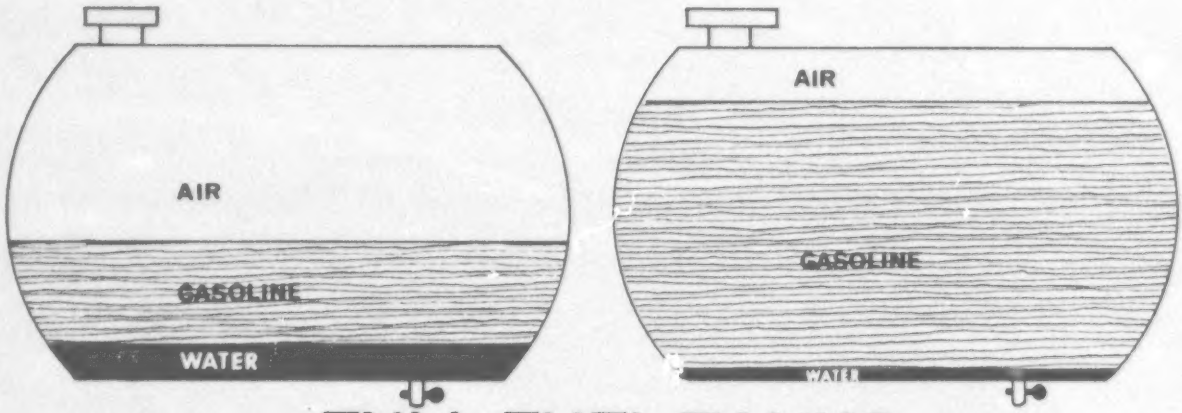


DIESEL FUEL SYSTEM

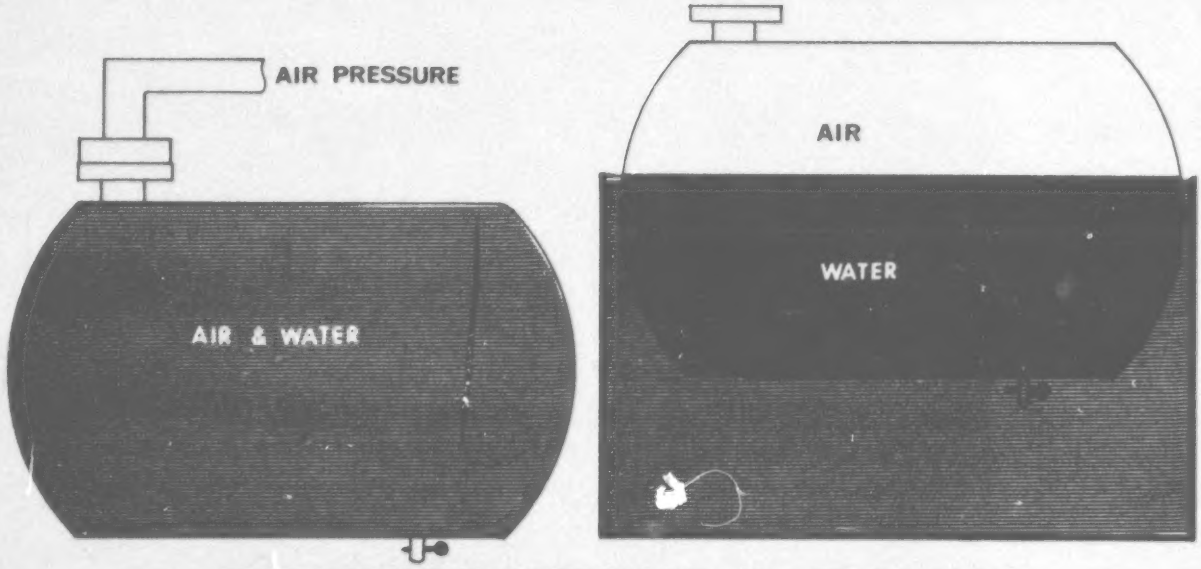


LP GAS FUEL SUPPLY SYSTEM

FUEL SYSTEM

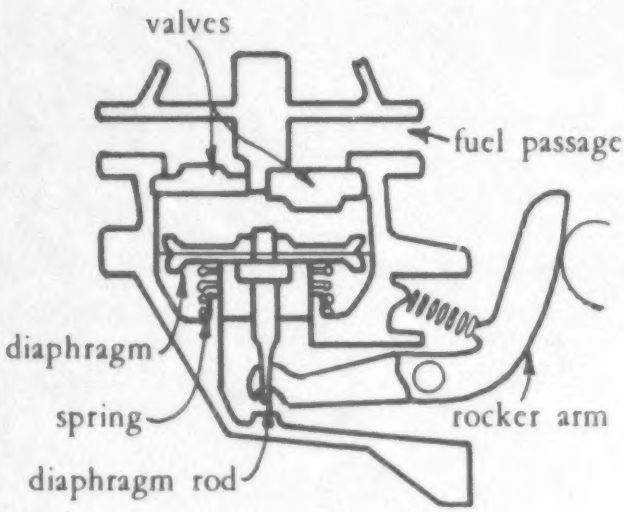


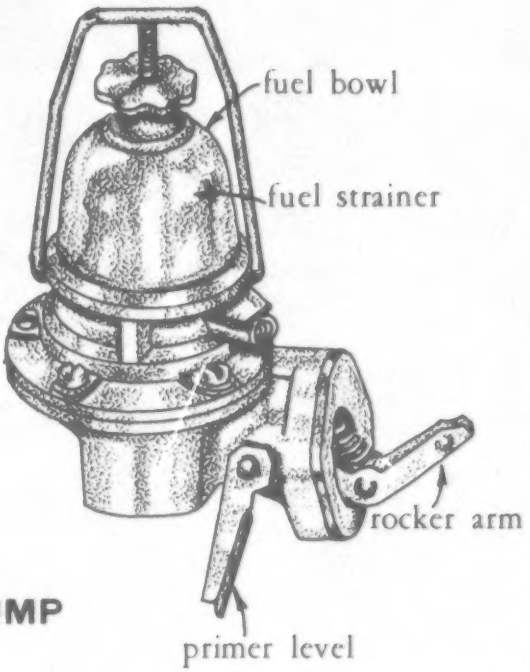
FULL FUEL TANKS COLLECT LESS MOISTURE



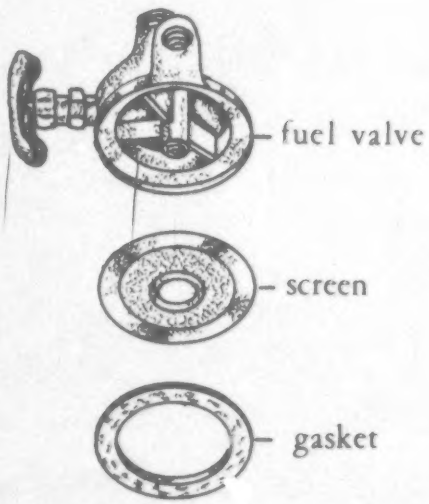
TESTING LEAKS IN TANKS

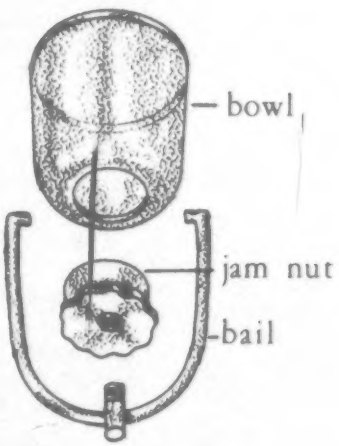
FUEL SYSTEM

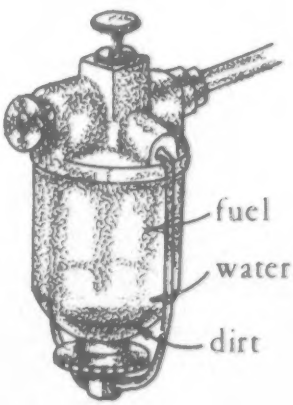




FUEL PUMP

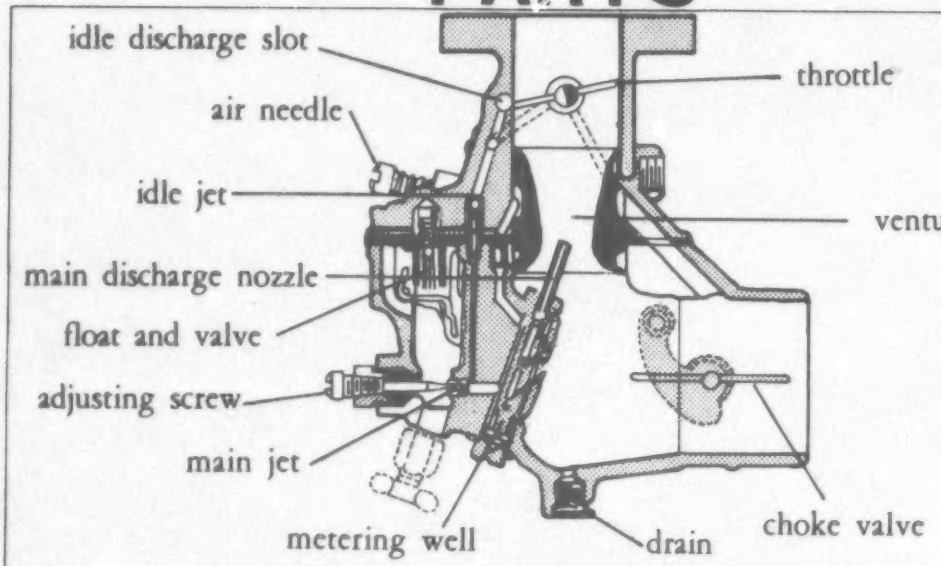




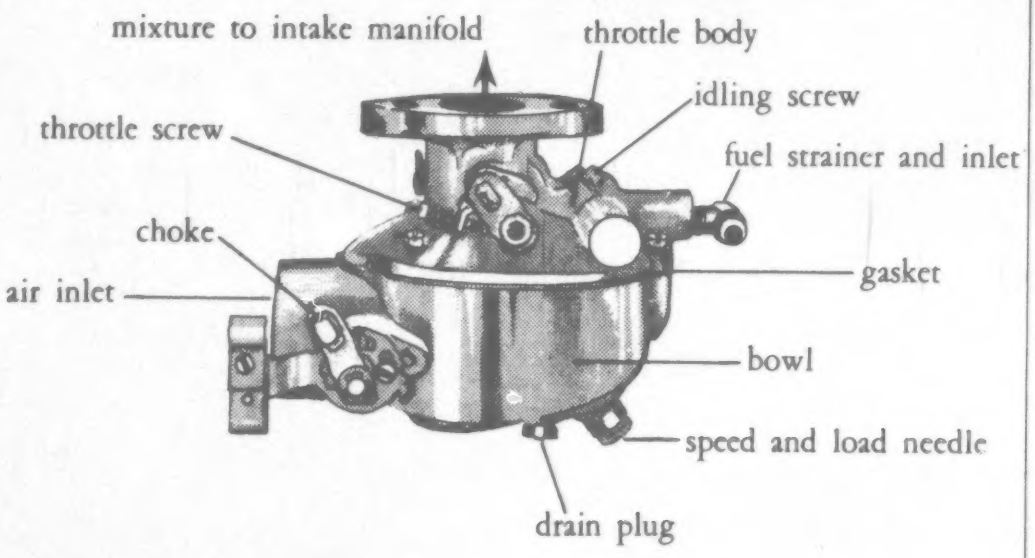


FUEL FILTER

GASOLINE CARBURETOR PARTS

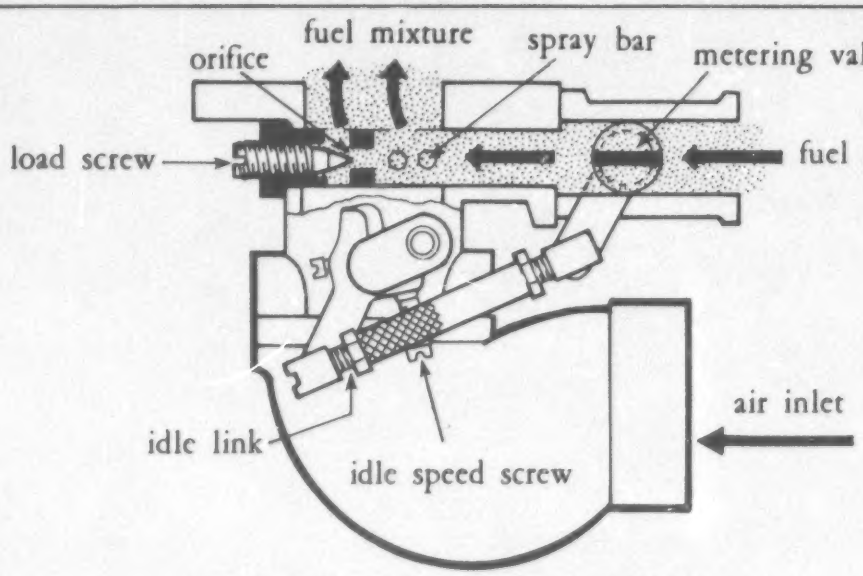


SINGLE VENTURI CARBURETOR

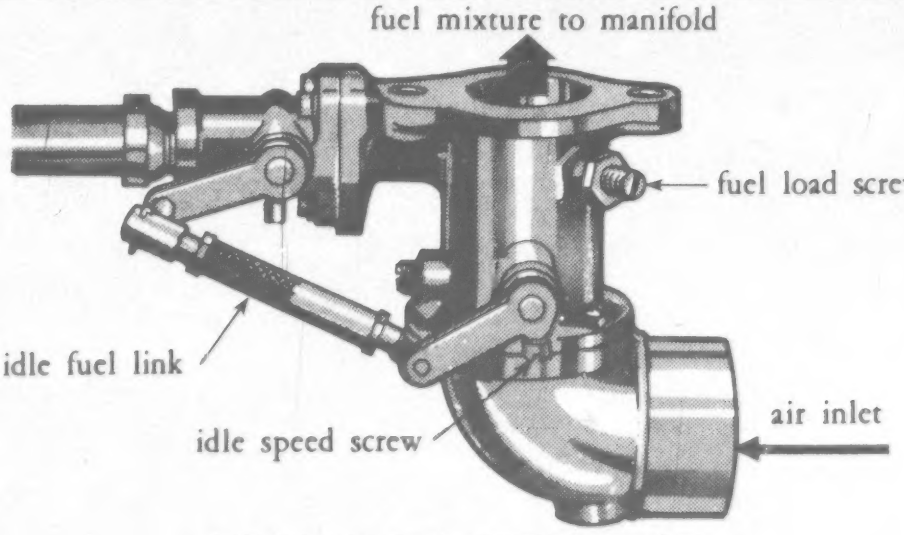


SINGLE VENTURI CARBURETOR

LP-GAS CARBURETOR PARTS

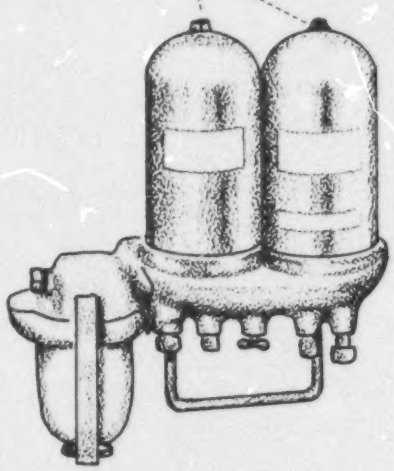


LP-GAS CARBURETOR

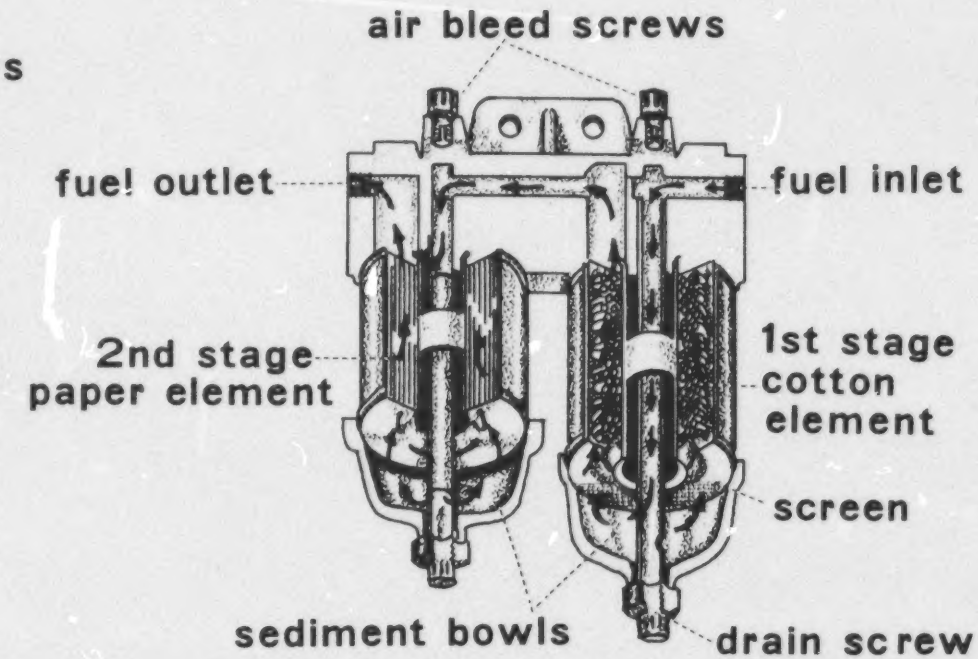


LP-GAS CARBURETOR

FUEL SYSTEM



Diesel Fuel Filters
With Separate
Sediment Bowl



Diesel Fuel
Filters Complete

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 3: Ignition

Suggested Procedure and Activities: The parts of a tractor electrical system may be used as teaching aids during the class discussion.

1. The Purpose and Kinds of Ignition Systems in Tractors

Transparency No. 1

a. Battery Ignition System - The battery ignition system consists of the following components: battery, ammeter, ignition switch, resistor, ignition coil, spark plugs, and high and low tension wiring. The generator or alternator may be considered part of the battery system.

Batteries consist of two sizes, 6 volt and 12 volt. There are three cells in a 6 volt battery and 6 cells in a 12 volt battery. A 12 volt battery has more power for lights and starting the tractor.

Transparency No. 2

b. Magneto Ignition System - The magneto system has nearly all the components found in a battery ignition system. The electrical current is generated by electro-magnetic indirection. Magnets rotate on a magnet shaft, moving the magnetic current. In every half revolution of the shaft, the flow of the current changes directions, creating the greatest flow just before the change in direction takes place.

The magneto ignition system consists of a distributor, rotor, coil, breaker points, condenser wires, spark plugs, and impulse coupling. The impulse coupling causes a spring to be wound up for part of a turn while the magneto is stopped; then, when it is suddenly released the magneto catches up with the engine, producing a hot spark. It also retards the spark to prevent the engine from kicking back.

The magneto ignition system was very popular on the early hand-cranked tractors. This system has been almost entirely replaced with the battery system.

c. Internal combustion engines operate on gases that burn and expand when ignited in the combustion chamber. Gasoline and LP gas engines require an ignition system to ignite the compressed air fuel mixture. In a diesel

engine, air is compressed in the cylinder which raises its temperature so that when fuel is injected near the end of the compression stroke, it ignites.

2. Function of the Battery Ignition System

a. Battery - The battery is considered the starting point of the ignition system. It supplies electrical current for starting the engine, regulates the voltage in the system, supplies current to other parts of the ignition system, and receives current input from the generator or alternator. It produces a current through a chemical reaction of the materials of the positive and negative plates. Positive plates contain lead peroxide (Pb O2), and negative plates contain spongy lead material (Pb). The liquid material (electrolyte) is made up of sulfuric acid 36% and water 64% ($H_2O + H_2SO_4$ = Electrolyte).

The discharge cycle of a battery begins when it is connected to a complete circuit. Lead sulfate ($PbSO_4$) is formed at both negative and positive plates as the battery is discharged. The sulfuric acid is diluted by the formation of water. As the lead sulfate increases, the voltage decreases. The chemical action between the electrolyte and lead plates reduces as the battery discharges. Usually more acid in the electrolyte means a higher charge.

b. Switch and Ammeter - There are several types of starter switches. One of the most common is the instant starter switch, either push button or key turn. The solenoid switch (combination of magnetic and mechanical) is energized from the battery. This switch shifts the starting motor (starter) pinion to engage the flywheel ring gear.

The ammeter is usually located on the dash board. It measures the amount of current flow from the generator to the battery and the amount of electricity used by lighting and ignition, and it identifies electrical problems in the generator, battery, and short and open circuits.

c. Ignition Coil - The coil contains two windings of wires: a primary winding of heavy wire and a secondary winding of fine wire. A low voltage current passes from the battery to the coil where it is changed to a high voltage current and delivered to the spark plugs. The voltage increase in the secondary winding may be as high as 25,000 volts. This voltage is high enough to cause an electric spark to jump the spark plug gap.

d. Distributor - The distributor distributes the high-voltage current from the secondary winding in the coil to the spark plugs. The current enters the distributor at the center through the cap. The current is picked up by the rotor and carried to each distributor terminal which is connected to one of the spark plugs.

Most distributors contain the breaker points and a condenser. The breaker points break the primary circuit, thus stopping the flow of current from the primary winding as the points separate. The coil is magnetized when the points are closed. When they are open, core magnetism is destroyed and a high voltage current (spark plug current) is produced in the secondary winding of the coil.

The condenser is a protector of the points, and it strengthens the primary current. It prevents the points from burning or sparking at the time they open. One part of the condenser is grounded, and the other part is connected to the primary circuit leading to the points.

e. Spark Plugs - The spark plugs furnish a spark to ignite the fuel mixture in the cylinder. The high voltage current passes through the terminal nut to the insulated electrode and jumps the gap to the grounded electrode.

f. Generator and Alternator - The alternator functions about the same as a generator, in that it converts mechanical energy into electrical energy. It functions as an a. c. generator. The alternating current is converted into direct current by diodes (current is allowed to pass through itself by means of an electrical device).

The advantages of using alternators:

The alternator is usually lighter and more compact; it supplies a higher current at a slower speed than the generator; it is better adapted to the newer a. c. charging circuits; and it easily supplies current on idling engines.

Generators have a moving conductor through a stationary field to produce voltage. This voltage, in the form of a. d. c. current, charges the battery and furnishes electricity for other electrical circuits. If the engine is idling slightly above normal, the armature is rotating fast enough to produce a current that flows through the ammeter to the battery. The amount of current produced will depend upon the speed of the armature.

g. Regulators - The electrical wiring system on a tractor is equipped with a cut-out relay regulator. The generator cut-out relay prevents the battery from discharging back through the generator when the engine is not running or when it is idling slowly.

There are three types of regulators found on tractors. They are made up of separate units and a combination of units. Usually, the cut-out relay and the current and voltage regulators are constructed to fit under one cover, but they are separated into three different units due to the three different functions they perform. The voltage regulator limits the heat and voltage produced by the generator. Current output is limited by the current regulator. It is important that the regulators function properly; otherwise, high voltage may cause lights to burn out and points to stick or pit and cause damage to the condenser and coil.

3. Maintenance of a Tractor Ignition System

Transparencies Nos. 3 and 4

a. Battery - The tractor battery is similar to a car battery, but it usually has a larger electrolyte capacity. The steps in maintaining a battery are:

Clean the battery with a damp cloth or brush, removing corrosion around the terminals, and use a baking soda and water solution to neutralize acid deposits.

Inspect and tighten all battery connections. If the cables are corroded, they should be removed from the battery and cleaned. The terminal posts should be cleaned with a steel brush. After the cables are tightened on the posts, a small amount of grease applied to the post and cable connection will retard further corrosion.

The electrolyte may be checked by using a hydrometer to determine the specific gravity of each cell. At 80 degrees F. electrolyte temperature, the specific gravity should be between 1.215 to 1.270. If there is a difference of 50 s. g. points (.050) between cells, the battery is not in proper condition.

One of the most important steps in maintaining the battery in good condition is to keep the electrolyte at the proper level by adding clean water.

b. Switch and Ammeter - The switch and ammeter should be replaced if they do not function properly. The wires leading to the switch and ammeter should be checked if problems arise in these units.

c. Ignition Coil - The terminals and connections should be checked periodically to make sure they are clean and tight. All rubber nipples should remain in good condition. Damaged rubber nipples on the high-voltage circuits will cause leakage of current where the surfaces are exposed.

If the coil becomes cracked or contains bad wiring, it must be replaced. Moisture that enters the coil will cause it to function improperly. If the coil seems defective, it should be tested with a meter-type coil tester. A coil testing lamp may be used to test the coil for grounded or open windings.

Transparencies Nos. 5a, 5b, 5c, 5d, and 5e

d. Distributor - The distributor is usually checked if the engine is hard to start, if the engine fires improperly, or if the engine uses an excessive amount of gasoline. Other procedures to follow are:

Check the distributor cap for burns and cracks. Damaged caps should be

replaced with new caps. Wash all parts to free them of dirt and grease. A soft rag dipped in kerosene makes a good cleaner for a distributor.

If it is necessary to remove the spark plug cables, they should be removed, inspected, cleaned, and replaced one at a time. The cables must be firmly set in the sockets.

Inspect the distributor rotor. It receives the high voltage current; therefore, it may be badly worn, burned, and the contact spring weak.

Check the condition of the distributor breaker points. The points may be maintained by keeping them filed smooth; that is if they are not burned and badly pitted. Set the points as recommended, grease the cam, and oil the felt pad.

Check the points to determine whether or not a point is formed on the stationary breaker point and a pit on the other. This condition is caused by a condenser lacking capacity. If the condenser capacity is too high, a point will be formed on the breaker lever point.

Check all spark plug wires for mechanical wear and defective insulation. These high tension wires may cause a voltage leak by grounding out the current. Weak voltage will cause a weak spark at the spark plug. The manual method used to test the distributor is to remove the lead from the spark plug and hold it 1/4 inch away from some metal part of the tractor engine. If a spark occurs as the engine makes its revolution, the distributor and wires should be functioning properly.

Transparencies Nos. 6a, 6b, and 6c

e. Spark Plugs - Most spark plugs should last about 250 hours under normal conditions. If spark plugs are well maintained, they will cause an engine to run smooth, save fuel, and maintain the engine's power.

Plugs should be checked every two or three months under normal operating conditions. The method of maintaining the plug in good condition is as follows:

Remove the plug and scrape hard deposits from it with a small-bladed knife. If possible, sand blast the inner socket around the electrode. Also clean the electrode insulation until it is white.

File the electrode flat and reset the gap as recommended for the engine. Wash the plug in a solvent to remove oils and dirt deposits.

Replace the plug gasket and install by completely tightening it with a spark-plug socket wrench.

Transparencies Nos. 7 and 8

f. Generator and Alternator- The generator is subjected to high, low, and variable speeds when the tractor engine is in operation. If a generator is kept in the proper operational condition, the following maintenance practices should be observed:

Remove the generator and replace the brushes if they have been worn less than half their original length. Set the brushes on the commutator by using fine sand paper. Use the grit side on the brush.

Inspect the commutator and clean it with a brush seating stone if it is dirty and has a glazed surface.

Check the cover band for solder deposits. If these deposits are excessive, send the generator to a generator repair shop.

The generator must be polarized before starting the engine. All wires must be connected before placing a jumper wire on the battery and generator regulator posts.

When replacing the generator on the tractor, check all connections for tightness. Check and adjust the drive belt or belts for proper tightness.

Alternators have been replacing generators on many of the modern tractors. Usually, there is less maintenance on an alternator than a generator. Service jobs on alternators are usually done by a skilled mechanic.

Transparency No. 9

g. Regulators - Some of the problems encountered with regulators are low setting, burned points, open series circuit, grounded generator field circuit, improper voltage setting, and a defective unit.

When checking a regulator unit use the following sequence of unit testing: first, check the voltage regulator; second, check the cut-out relay; and third, check the current regulator.

The entire charging circuit should be checked to determine which component is failing. All connectors, leadwires, and circuit components should be checked. An electrical check should be made with a voltmeter, tachometer, and resistance unit. The regulators should be at operating temperature before tests are made.

Use the guide or service manual as a reference for cleaning the contact points.

4. A Complete Electrical System

The tractor's electrical system is comprised of four major circuits. These circuits and their components are:

a. Charging Circuit (DC)
Generator
Regulator
Ammeter
Battery

Charging Circuit (AC)
Alternator
Regulator
Ignition Switch
Ammeter
Battery

b. Starting Circuit
Battery
Starter Switch
Motor Switch
Starting Motor
Flywheel

c. Ignition Circuit
Battery
Ignition Switch
Coil
Distributor
Spark Plugs

d. Light Circuit
Battery
Indicator Lamps
Light Switch
Circuit Breakers
Main Lights

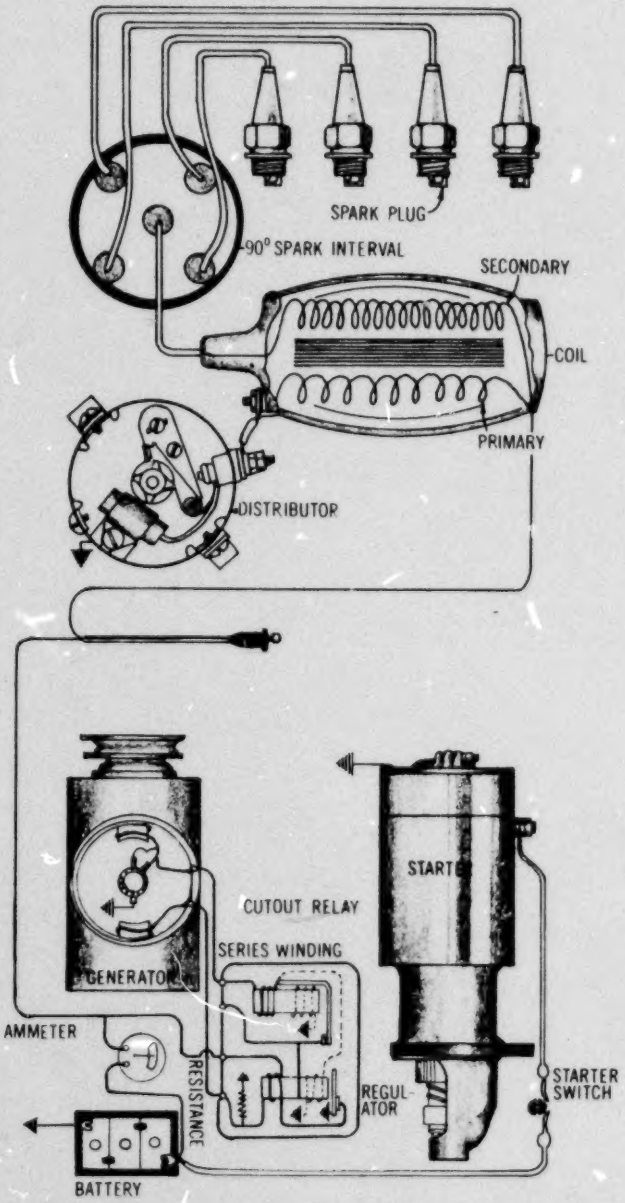
References:

Stone, Archie A. and Harold E. Gulvin, Ma chines for Power Farming, John Wiley and Sons, Inc., New York, NY, 1967

"Fundamentals of Service-Electrical Systems", Deere and Company, Moline, IL, 1972

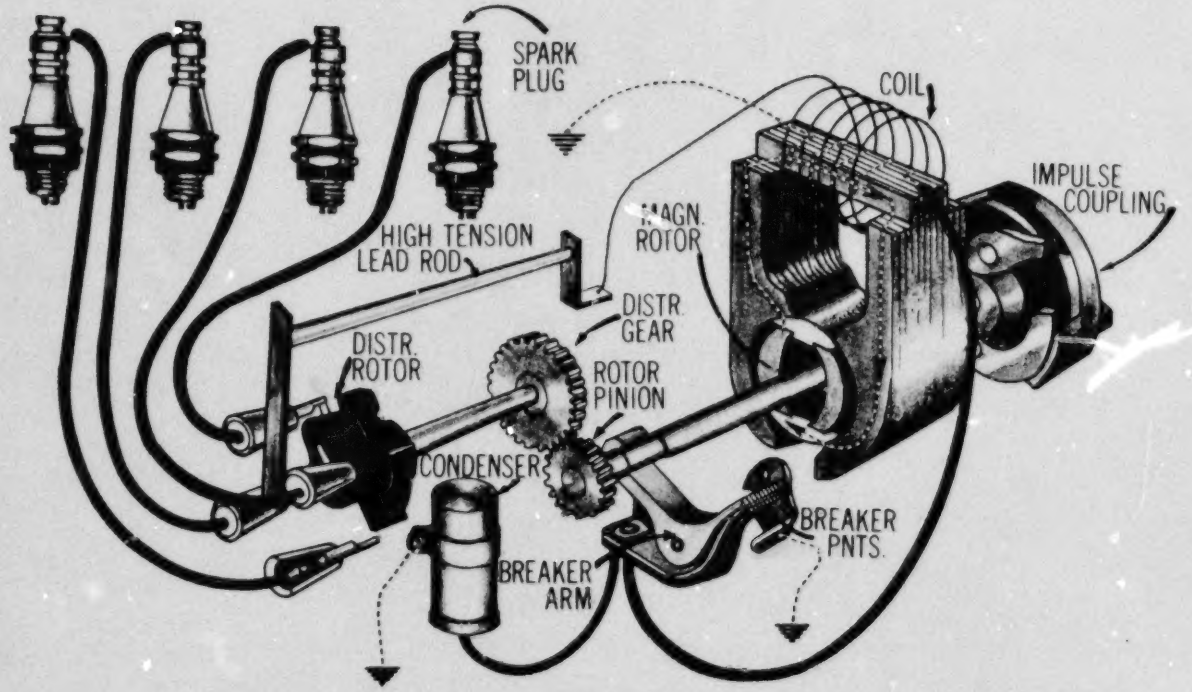
"Tractor Maintenance; Principles and Procedures", American Association for Vocational Instructional Materials, Athens, GA, 1975

IGNITION SYSTEM



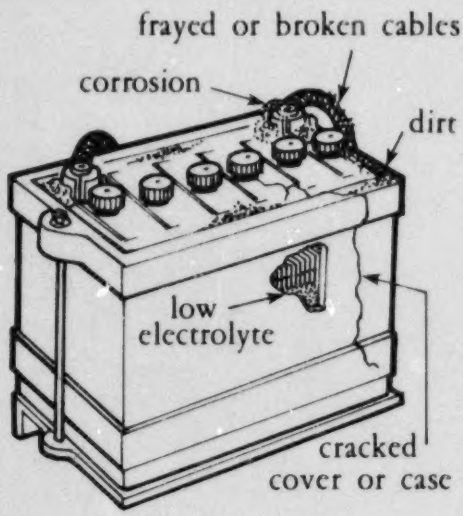
BATTERY SYSTEM

IGNITION SYSTEM

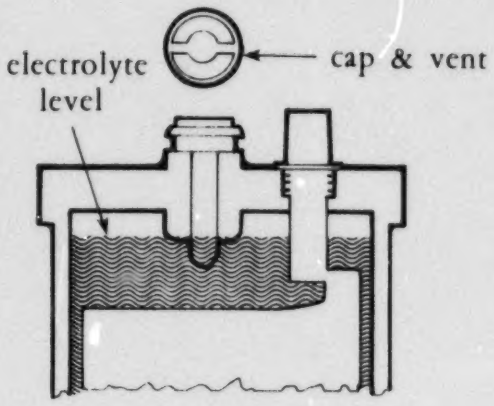


MAGNETO SYSTEM

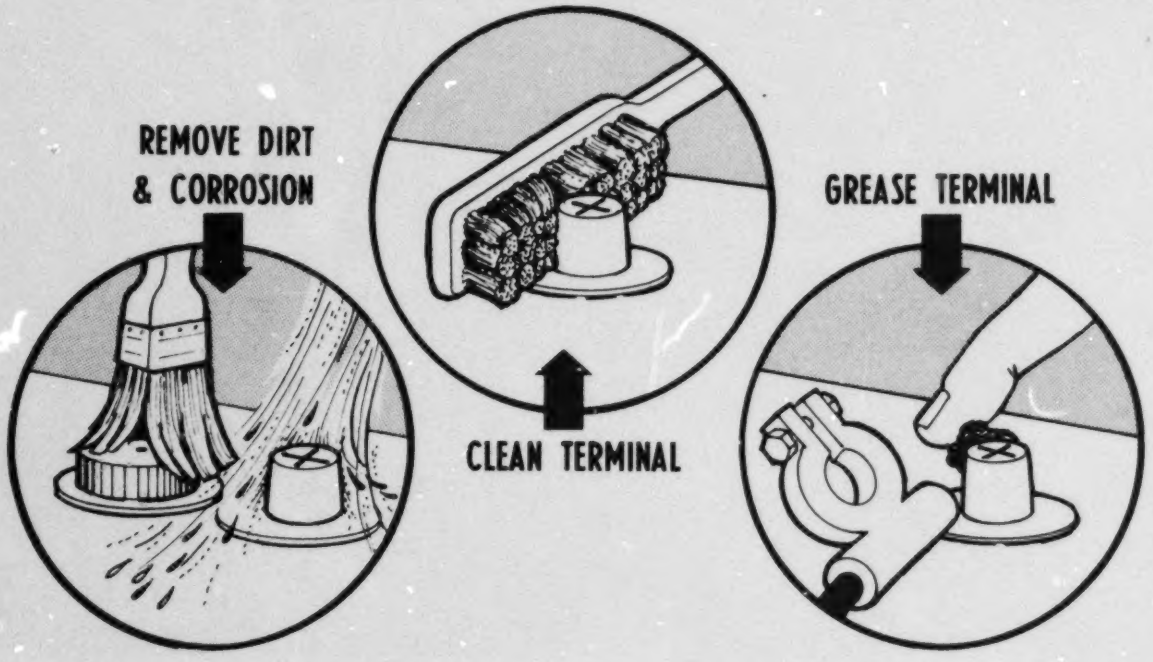
CARE OF BATTERY



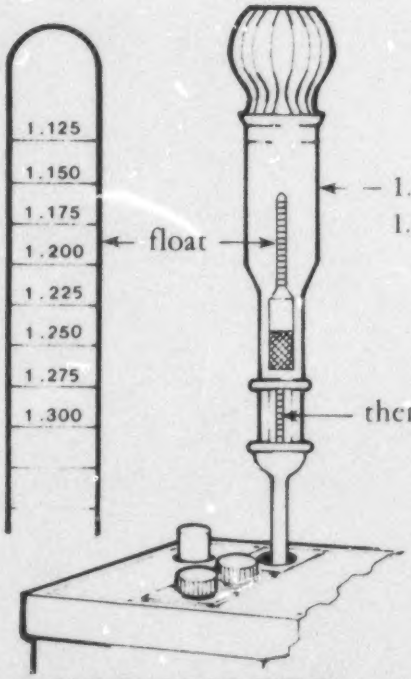
BATTERY LIFE FACTORS



PROPER ELECTROLYTE LEVEL

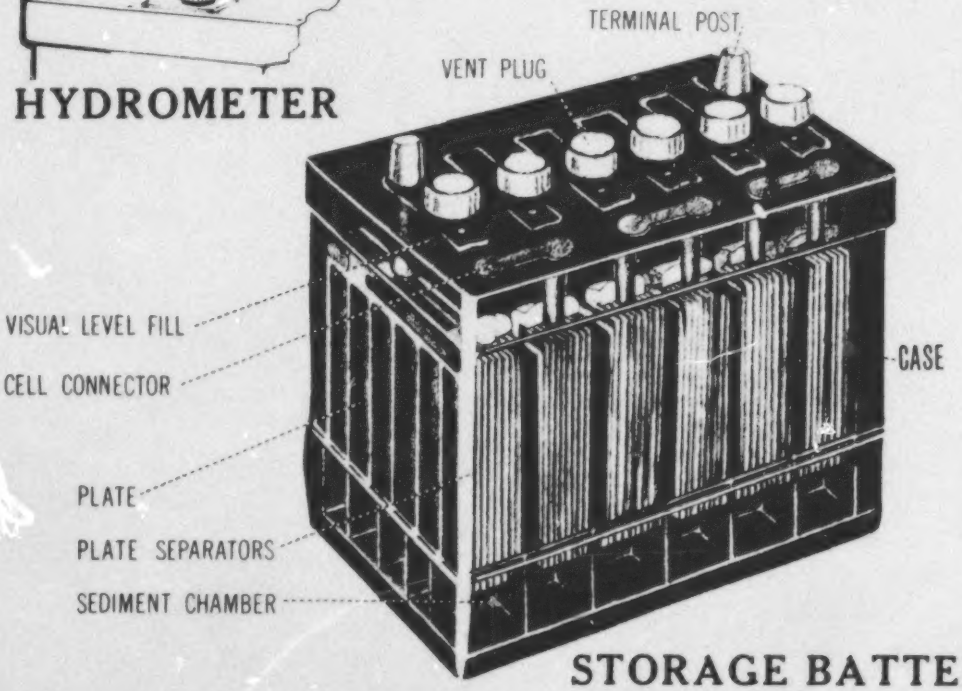


SERVICING THE BATTERY



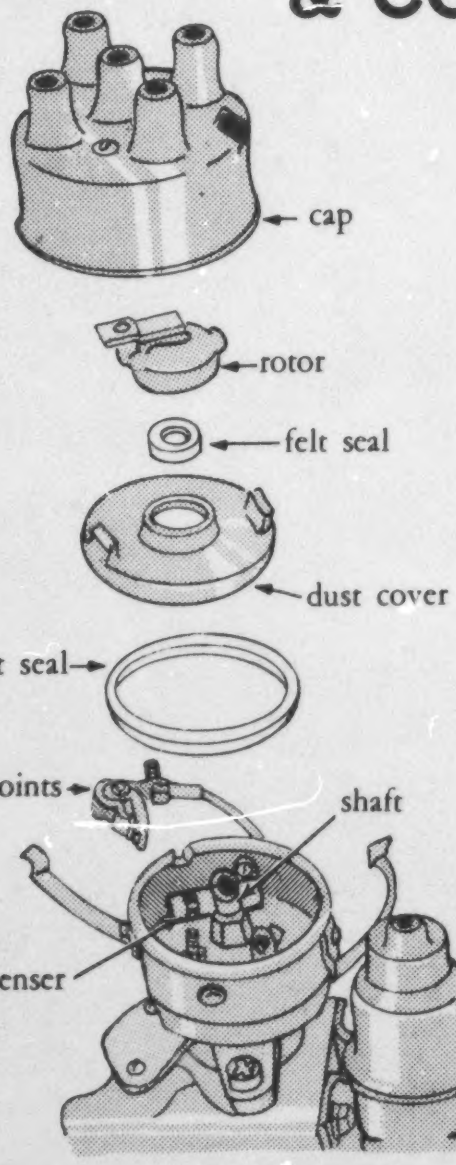
HYDROMETER

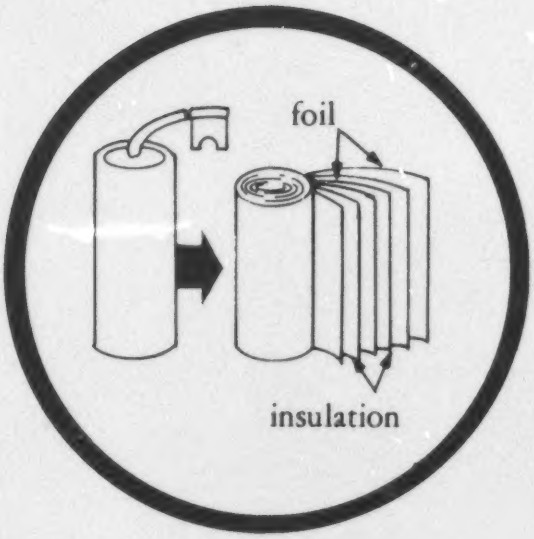
VOLTMETER



STORAGE BATTERY

DISTRIBUTOR & CONDENSER

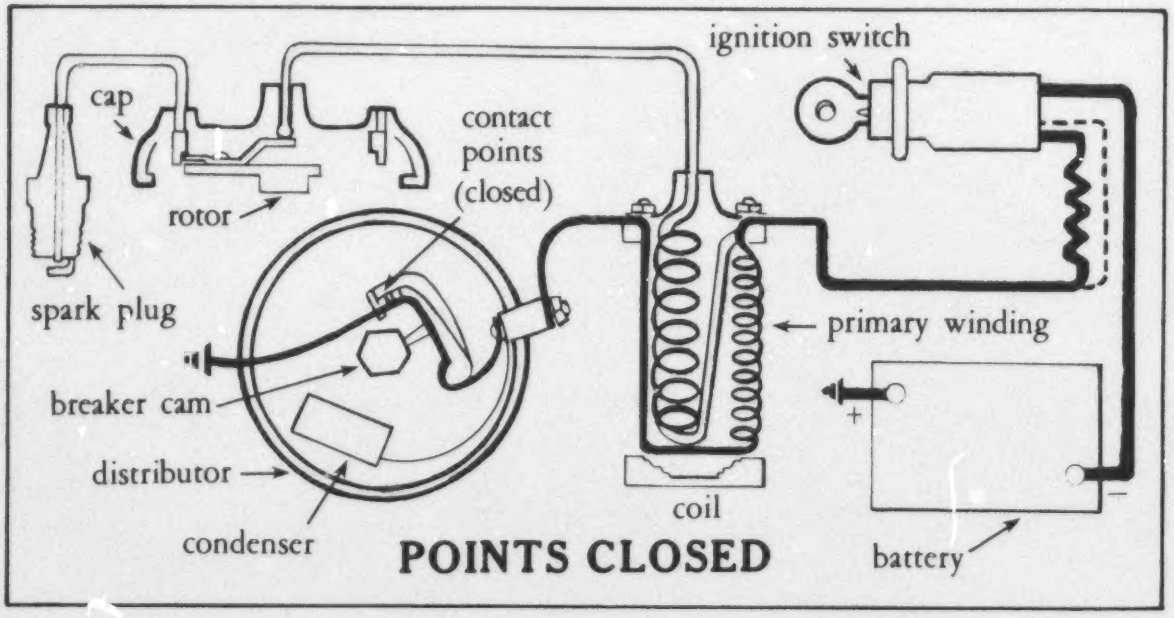




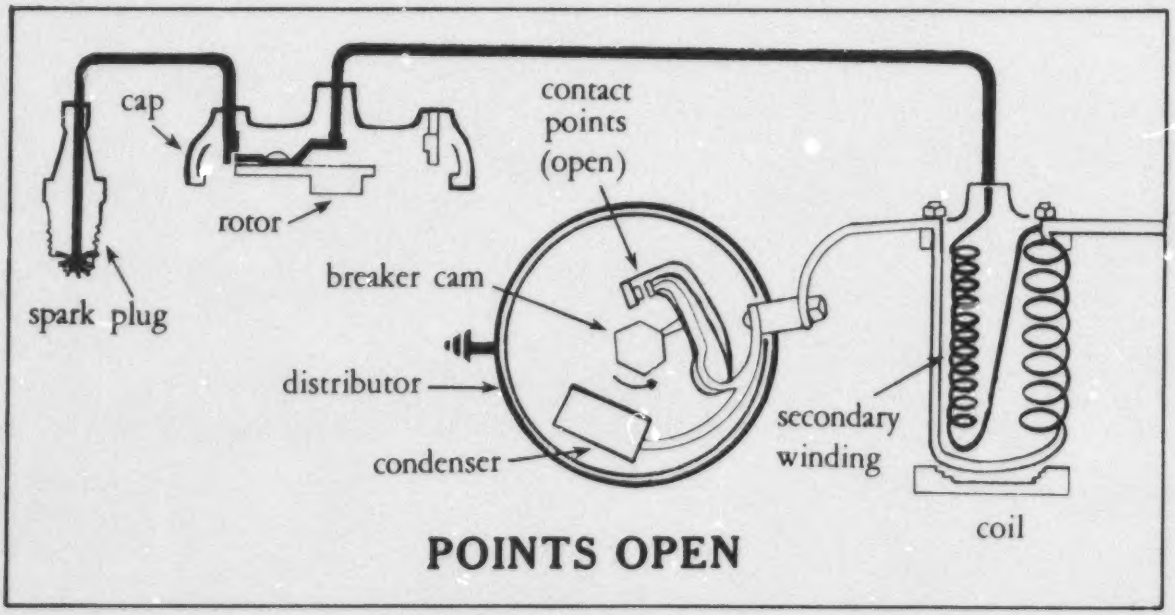
CONDENSER

IGNITION DISTRIBUTOR

IGNITION CIRCUIT OPERATION

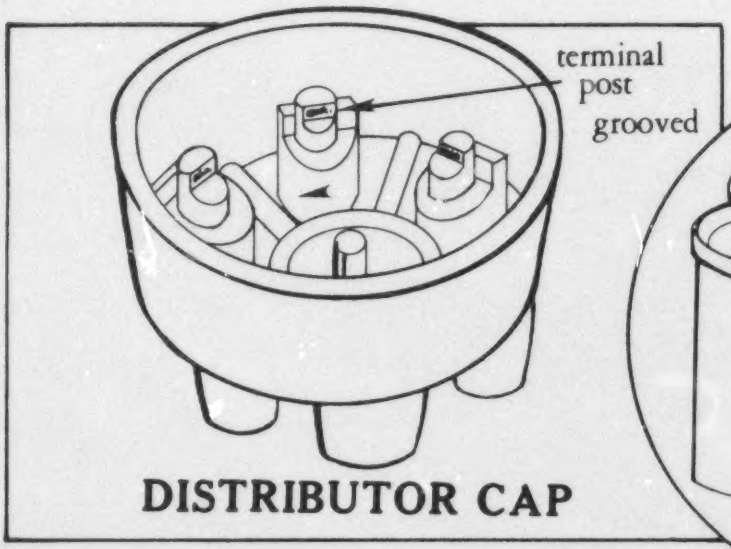


POINTS CLOSED

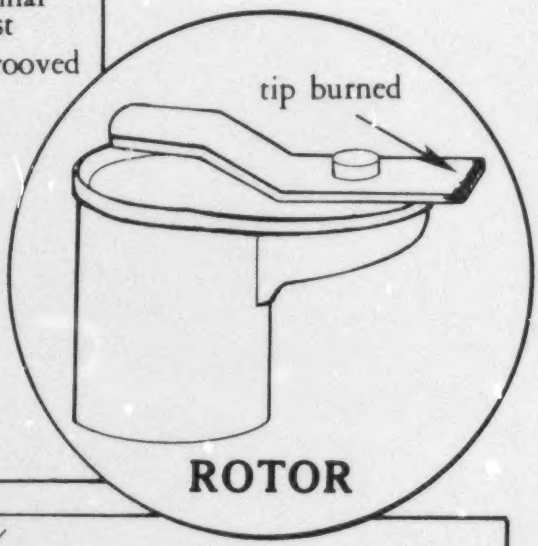


POINTS OPEN

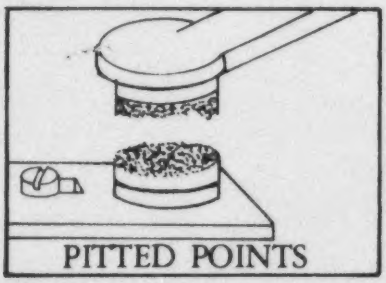
CHECKING THE DISTRIBUTOR & RELATED PARTS



DISTRIBUTOR CAP



ROTOR



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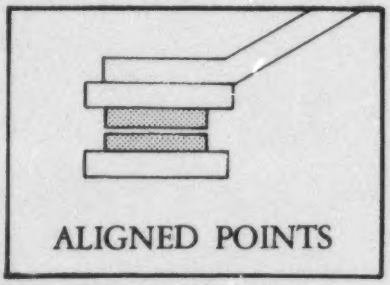

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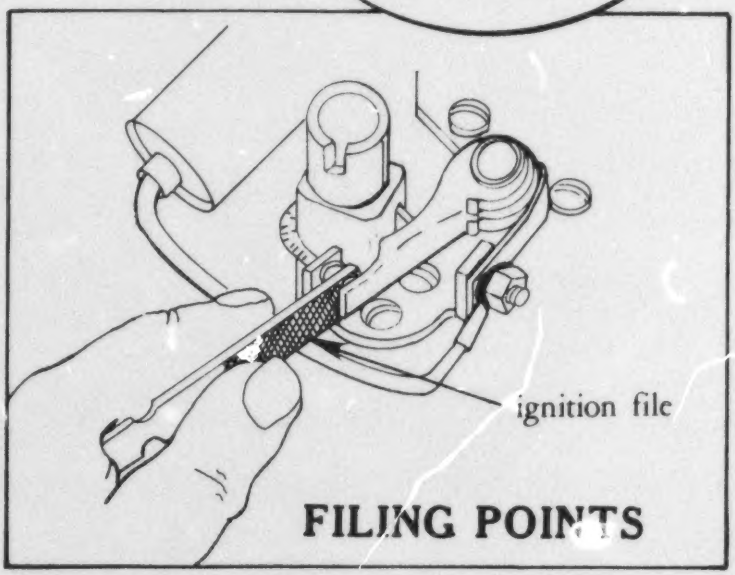
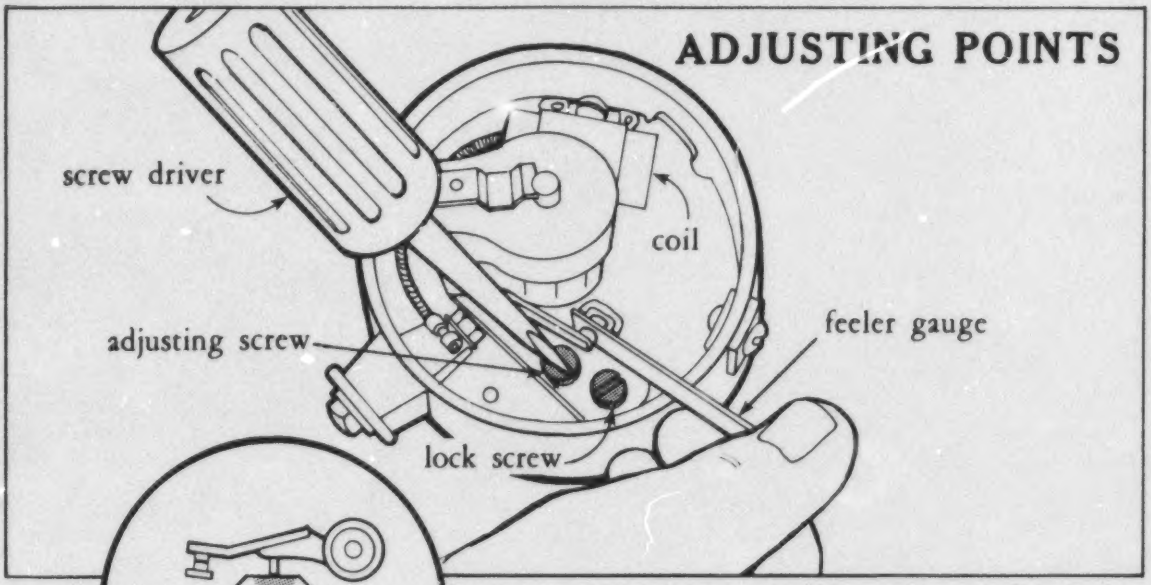
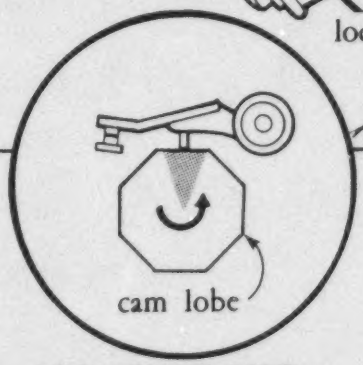


FILING POINTS

REPLACING AND ADJUSTING DISTRIBUTOR AND RELATED PARTS





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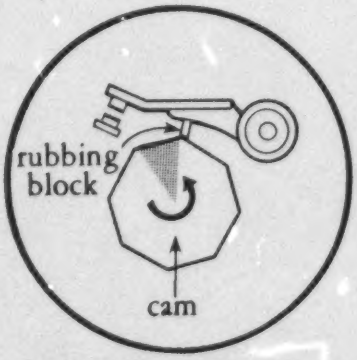

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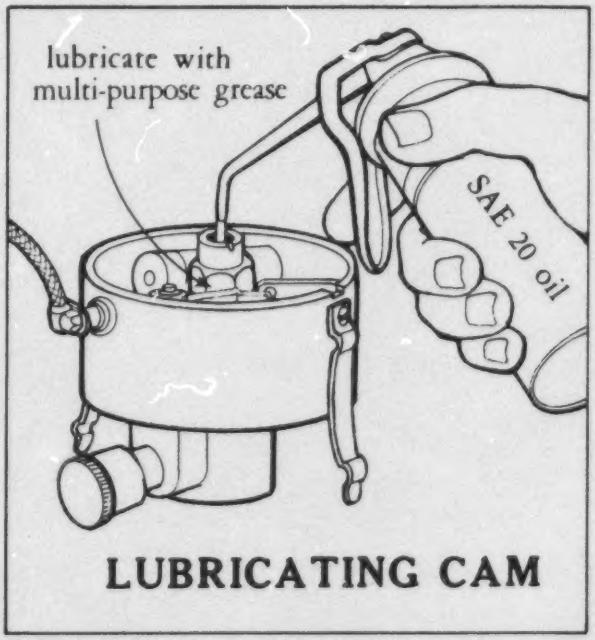
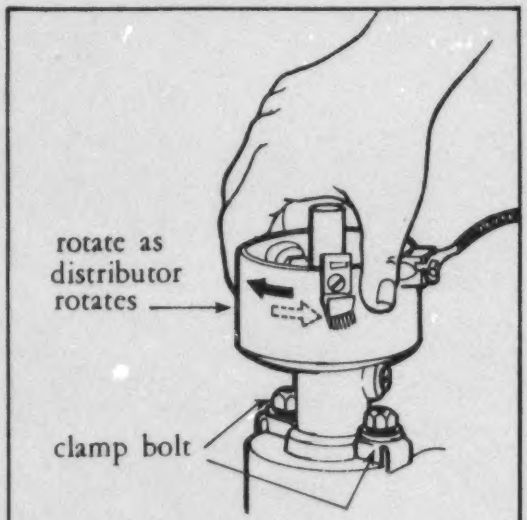
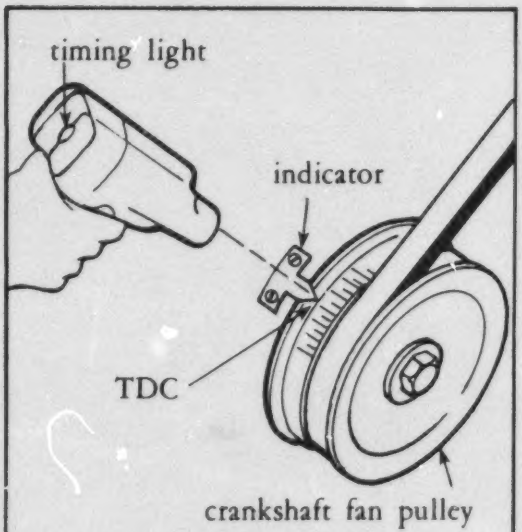


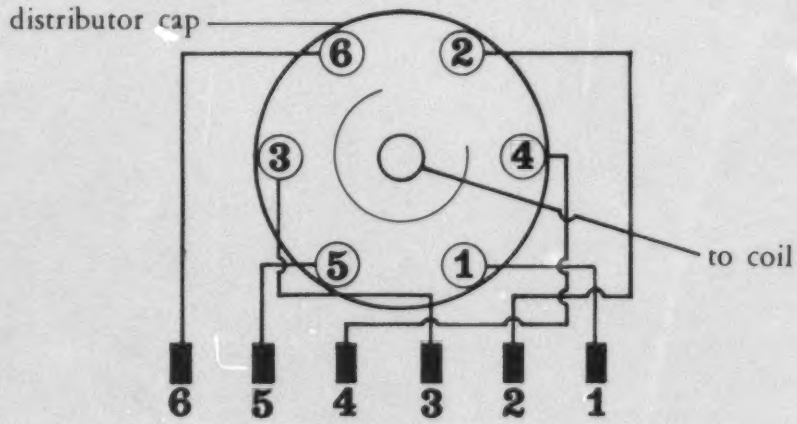
TIMING THE ENGINE



DISTRIBUTOR

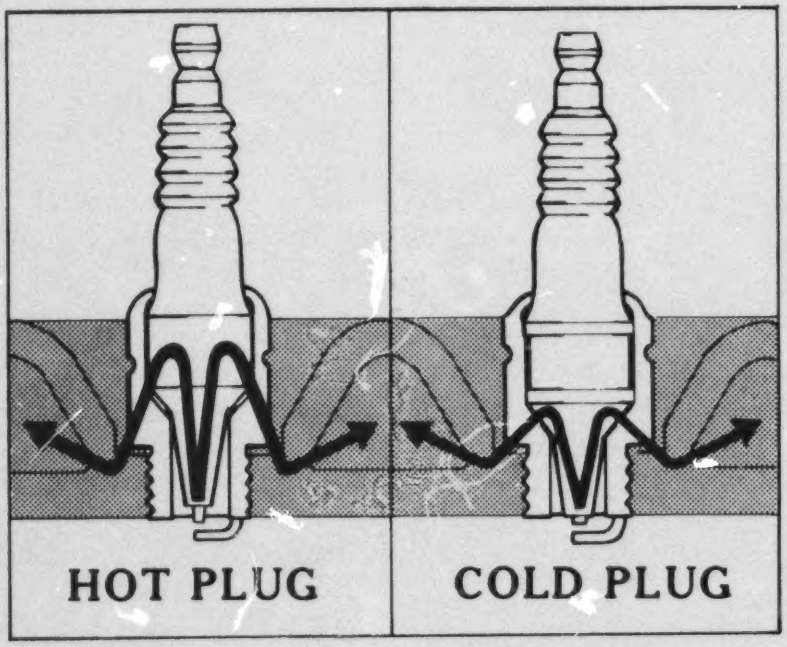


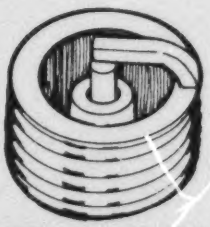
TIMING WITH LIGHT



FIRING ORDER - 1,5,3,6,2,4

SERVICING SPARK PLUGS

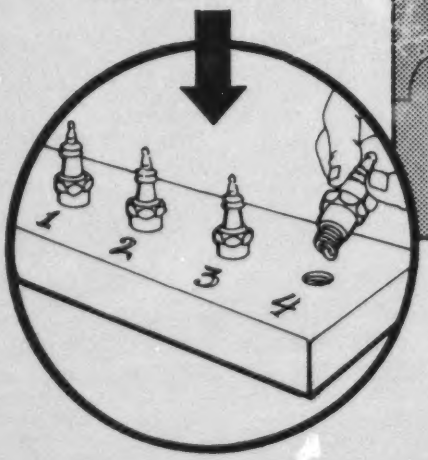


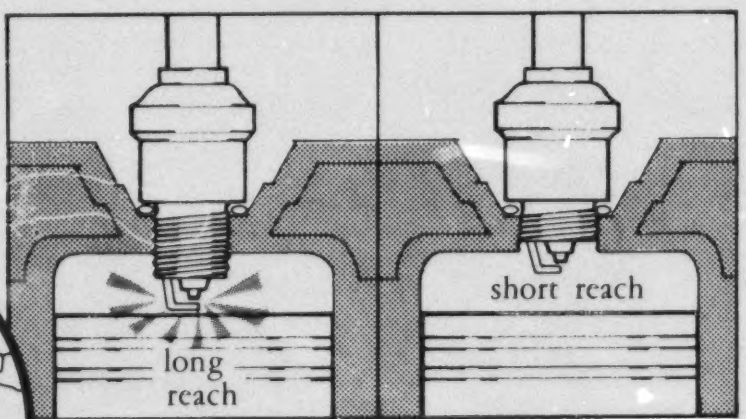


NORMAL PLUG

SCAVENGER DEPOSIT

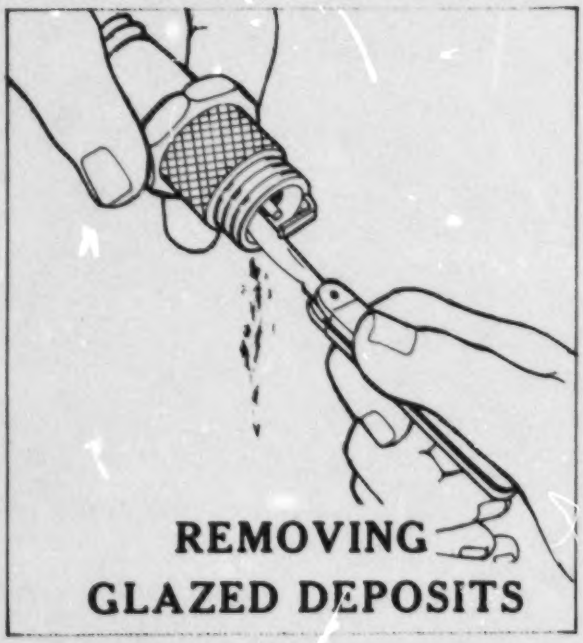
ORDER OF REMOVAL



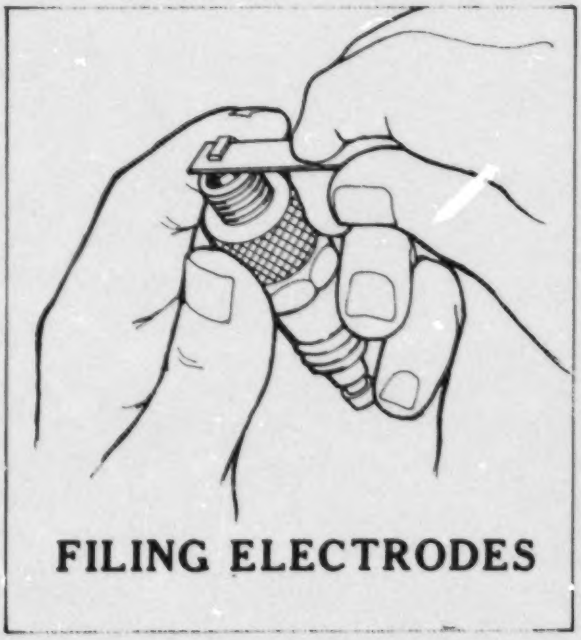


IMPROPER PLUG REACH

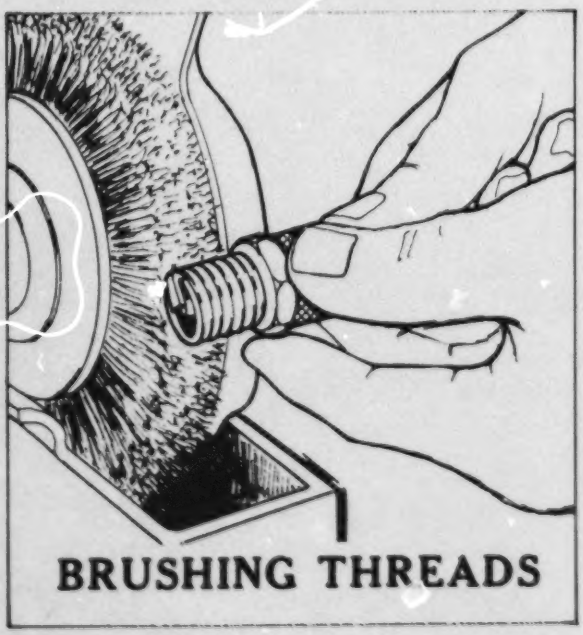
SERVICING SPARK PLUGS



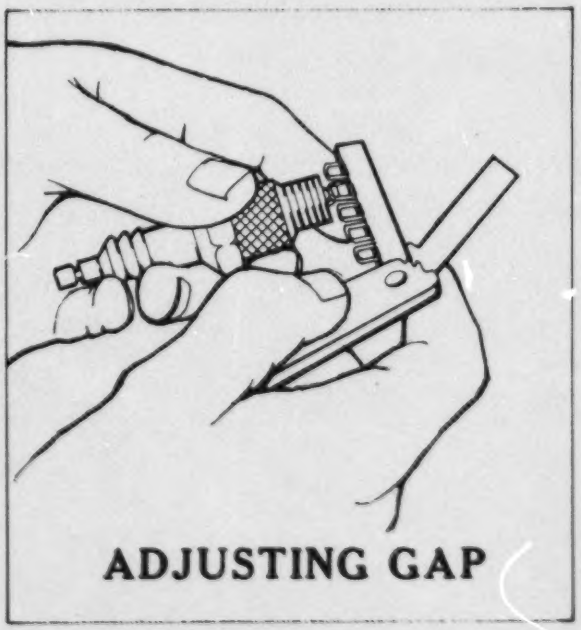
REMOVING GLAZED DEPOSITS



FILING ELECTRODES

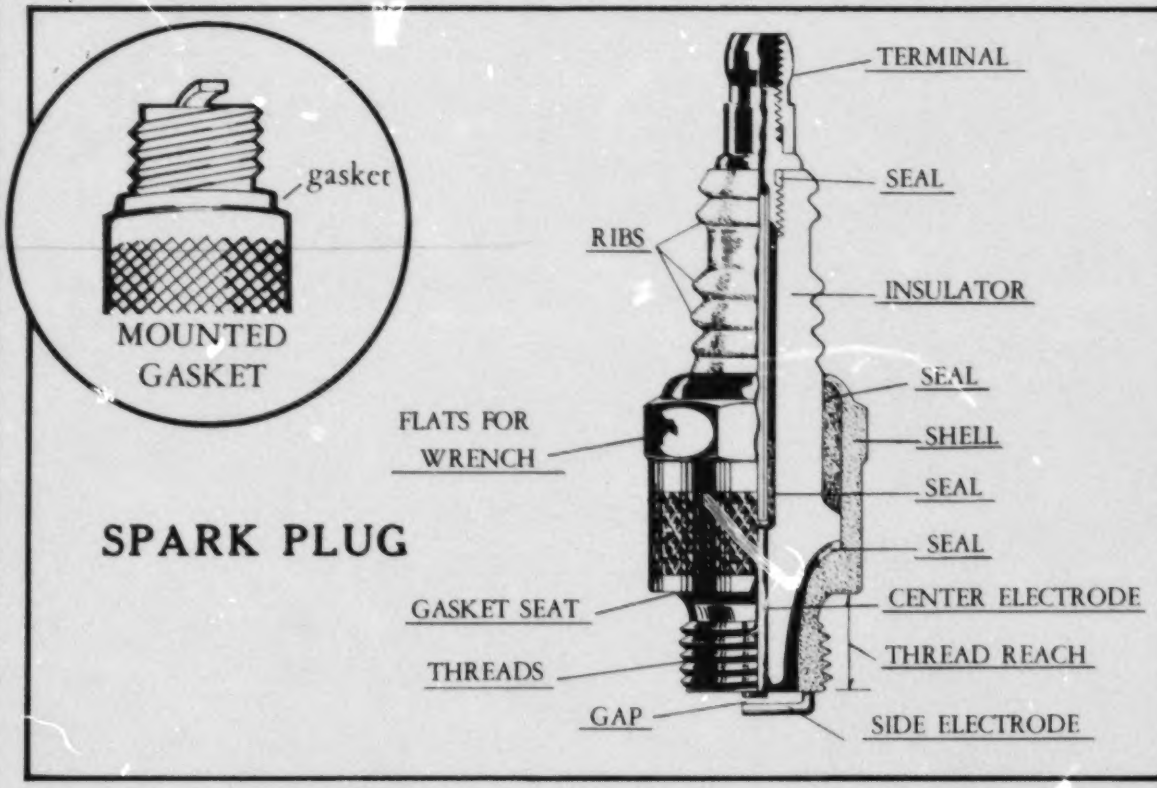


BRUSHING THREADS

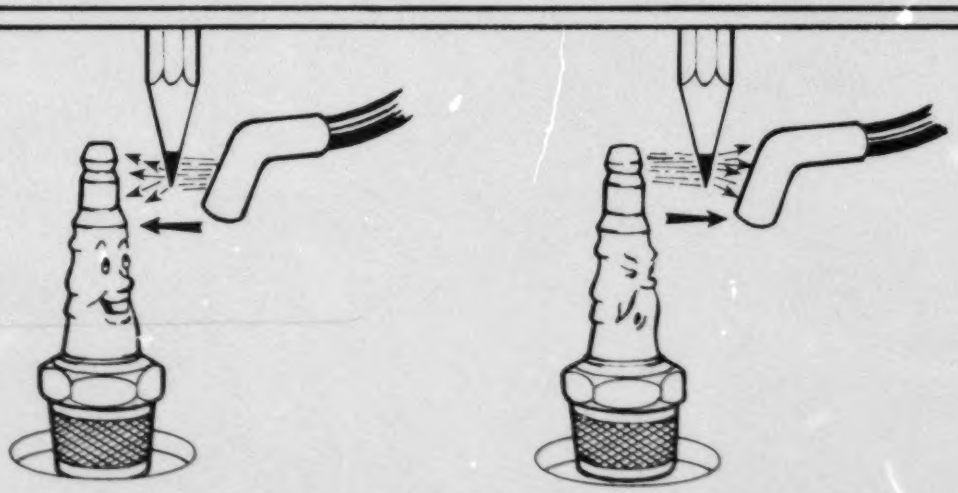


ADJUSTING GAP

SERVICING SPARK PLUGS

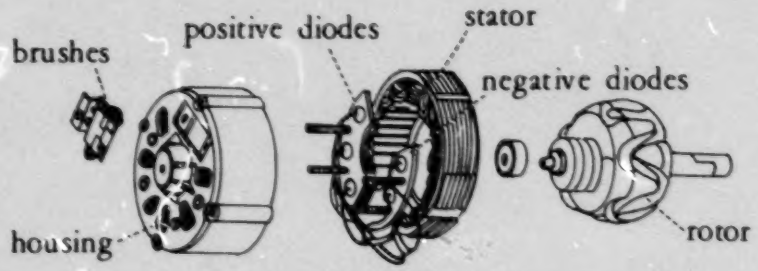


SPARK PLUG

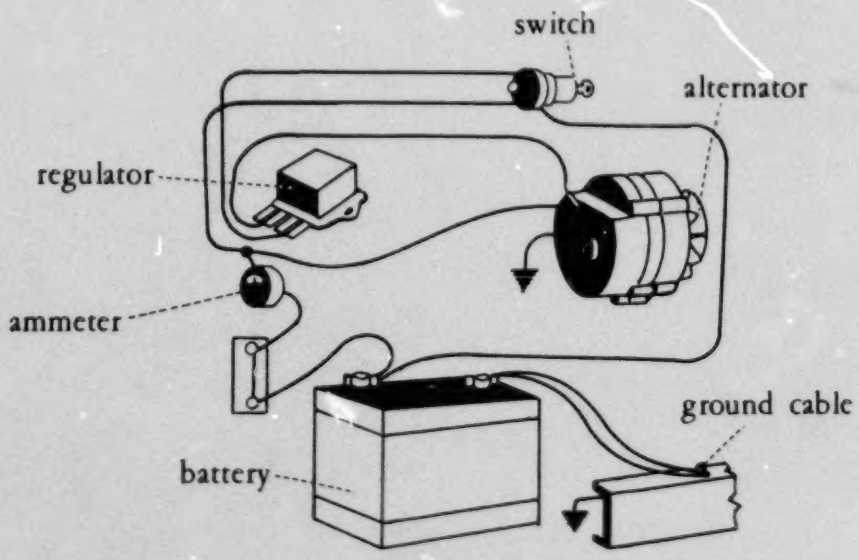


POLARITY AT PLUG TERMINAL

ELECTRICAL SYSTEM



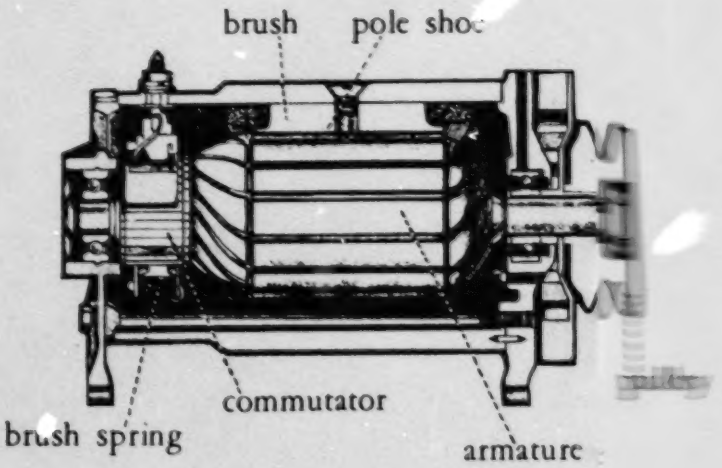
ALTERNATOR

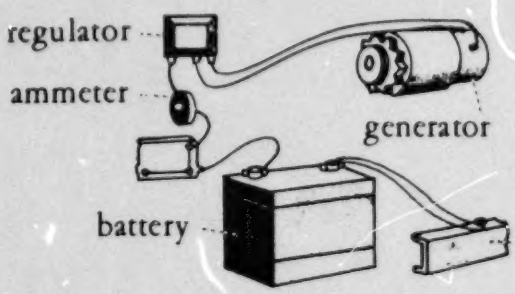


BATTERY CHARGING CIRCUIT – AC

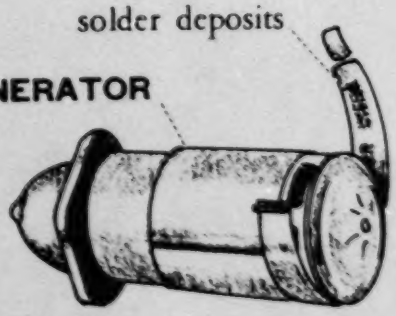
ELECTRICAL SYSTEM

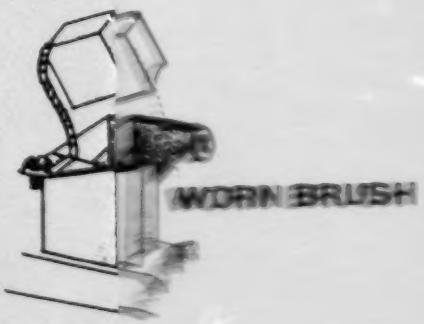
DC GENERATOR



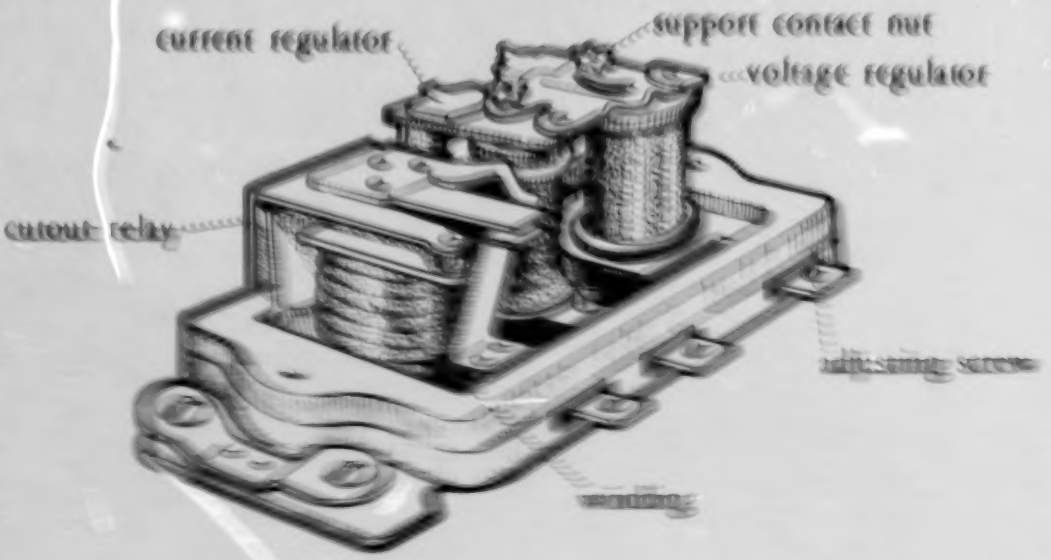


BATTERY CHARGING CIRCUIT - DC

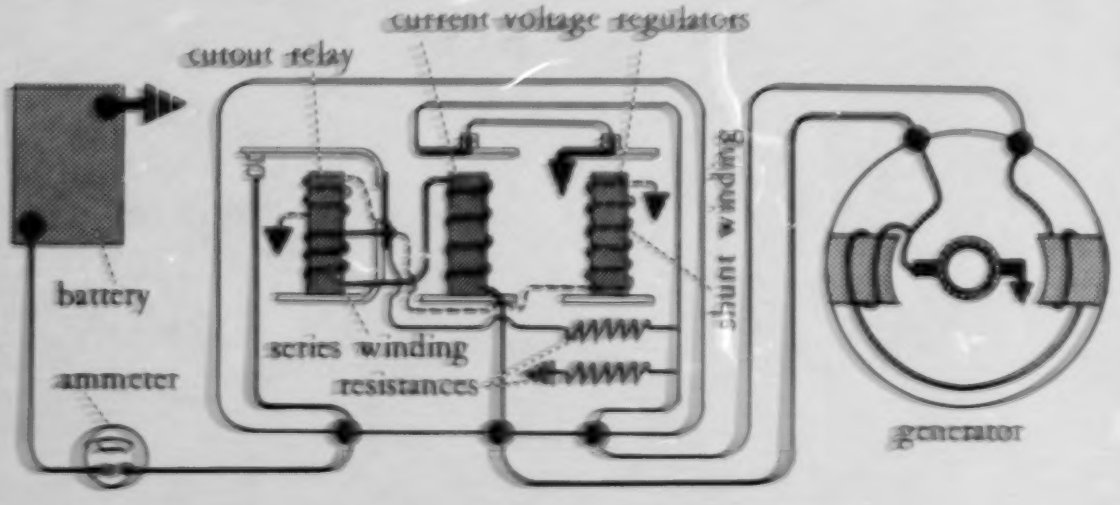




ELECTRICAL SYSTEM



REGULATOR UNITS



THREE REGULATOR UNITS

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 4: Lubrication

Suggested Procedure and Activities: Samples of the different grades and service classifications of lubricating oils and greases may be helpful as teaching aids during the class discussion.

1. Proper Use of the Operator's Manual

One of the most important practices in maintaining a tractor in working condition is to keep it properly lubricated. The operator should use the "Operator's Manual" as a guide for all lubrication jobs. The owner of a new tractor is furnished a manual for the model of tractor purchased. The buyer of a used tractor may not receive an operator's manual. Therefore, lubrication recommendations should be requested from the tractor dealer.

Most manuals give the following information about lubricating a tractor:

a. The parts of a tractor to be lubricated daily and after a certain number of hours of operation.

b. The grade of oil to use in the crankcase when the tractor is operated at different seasonal temperatures. Oil is graded according to its viscosity test, SAE grade. The SAE (Society of Automotive Engineers) chart may be used to determine the SAE grade. Oil with a viscosity number 20 is more resistant to flow then an oil number 40 (SAE grade).

c. The type and weight of grease to use on various parts of the tractor. For example, No. 2 multi-purpose lithium grease is used in a grease gun to grease parts supplied with grease jets.

d. The amount of oil and approximate amount of grease to use for various parts on the tractor.

e. The method to use for checking oil and grease needs and a description of the job to be done.

f. A list of tractor parts that require disassembly and assembly when lubricating.

The section on lubrication found in the Operator's Manual should be studied before attempting lubrication jobs. Maintenance and repair expense is greatly reduced

by keeping the tractor well lubricated.

2. Function of Oils and Greases

Without the use of proper oils and greases on most working parts, a tractor would cease to be operative within a few minutes. The surfaces of some bearings have a clearance of one ten-thousandth of an inch. Close tolerances in the bearing generate heat of friction that must be removed or carried away from the moving parts. Oil of the proper type, correct weight, and good quality functions in the following ways:

a. It minimizes friction between metal parts or metal surfaces thus reducing wear to the lowest possible degree. The same lubricating film that prevents wear also prevents friction.

b. It carries off heat by moving the heat to cooler areas. Heavy oils give quieter operation, but they do not carry off heat as effectively as light oils.

c. It serves as a solvent by carrying away carbon, dirt, and other foreign material that may damage the metal parts.

d. It prevents the loss of engine power by preventing a blow-by of combustion gases.

Hydraulic systems are operated by hydraulic oils. These light weight oils serve as fluids for operating hydraulic units, rather than as lubricants for moving parts.

The major functions of greases are to prevent friction, keep the moving parts clean, and help control heat caused by friction on certain moving parts.

3. Functions of the Oil Pump

There are two major types of oil pumps found on tractor engines: the rotor pump driven from the crankshaft and the external pump driven from the camshaft. These pumps are found on the full internal force feed, circulating splash, and internal force feed and splash lubricating systems. The functions of these pumps are similar, in that oil is forced through the oil system. The functions of the two pumps are as follows:

a. Rotor Pump. The rotor pump consists of an outer rotor ring and an inner rotor that turns inside the ring. Only one lobe of the rotor is engaged with the ring at any one time. As the inner lobes pass in and over the outer lobes, oil is drawn in and a seal is formed. Oil is squeezed out as the inner lobes fall into the ring cavities.

b. External Pump - Two gears are fitted inside a housing to form the main body of the pump. Oil is picked up in one side of the housing and forced out through the outlet and transferred through the entire oil system.

4. Functions of Filtration Systems

All tractor engines have some type of filter system to remove dirt particles, carbon, and other materials that contaminate the oil. If abrasive materials are not trapped and held away from the bearings in the engine, the life of the engine will be reduced due to rapid wear.

Transparency No. 1

a. The two types of filtration systems used in tractors are the full-flow and partial (bypass) flow. All the crankcase oil passes through the filter in the full flow system, whereas in the partial - flow system, only a small amount of the oil passes through the filter at one time. A combination of the partial and full flow systems is used on the large tractor engines.

It is estimated that between five and ten percent of the oil is pumped to the filter in the partial-flow system. The remainder of the oil passes to the bearings. The restriction in the filter also determines the amount of oil that passes through it. The amount of filtered oil may be less than ten percent as the filter becomes clogged.

Transparency No. 2

b. There are two major types of oil filters used on tractors. They are:

Depth Filters - The oil moves in many directions due to the volume of filter material encased in the element. The two types of depth filters are absorbent and adsorbent. Both types of filters will soak up impurities, but the absorbent filter is chemically treated to remove contaminants.

Surface Filters - Oil passes from the oil pump through filter holes in a straight line. The straining process stops dirt and other particles outside the single surface.

5. Oil Lubricating Valves and Pressure Indicating Systems

Transparency No. 1

Lubricating valves are considered a very important part of the lubricating system. These valves regulate oil pressure, bypass oil at oil coolers, and bypass oil at filters. The functions of these valves are as follows:

a. Pressure Valve - If the oil pump forces out more oil than is used in engine lubrication, the valve opens and returns the extra oil to the crankcase. The valve maintains the oil at a certain pressure in the lubrication system.

b. Bypass Valves - The filter and cooler bypass valves permit the oil to flow directly to the crankcase if the filter or cooler becomes clogged.

c. Pressure Oil Gauge - Pressure is usually read in pounds per square inch (psi). In the mechanical and electrical indicating systems, oil pressure is the main factor in regulating the gauge. The diaphragm and tube are the major sending units used on tractors.

6. Function of the Crankcase Ventilation System

Transparency No. 2

The ventilation system circulates fresh air through the engine. If moisture and fuel vapors are allowed to build up in the engine, there will be an accumulation of sludge and other contaminants. These vapors are removed by the following methods:

a. Lower air pressure at the vent tube causes air to enter the engine breather and circulate through the engine and out the breather tube.

b. In the intake manifold ventilation system, the intake vacuum pulls air into the engine and sends it out the exhaust system.

c. A vane pump is used on some tractors to pump air from the air cleaner into the crankcase. The air forces vapors into the intake manifold where they are burned.

d. In the breather-cap method the crankshaft and piston movement causes air to flow through the cap.

7. Maintenance of the Engine Lubricating System

a. Oil Pumps - These pumps do not need servicing after a certain numbers of hours of operation. Teeth in gear pumps and lobes in rotor pumps will show some wear after a year or two of operation. The clearance height of gears in the housing and the clearance between gears and the housing sides should be checked with a feeler gauge. A micrometer may be used to check the width of the gears and drive shaft wear. Use a service manual for the correct specifications.

Transparency No.3

b. Filtration System - The oil filter element should be replaced in some makes of tractors between 100 and 250 hours of operation, that is if the tractor is operating under normal conditions. If the tractor is operating in dust and chaff, the filter should be changed more often.

Before removing the filter element, remove the filter drain plug and allow the oil to drain out. Replace the filter element. If the filter is a throw-away type, it should be removed and replaced with a new filter.

The crankcase oil should be changed at the same time the filter is changed; otherwise, dirty oil will be passing through the new filter. Refill the crankcase to the full mark on the oil gauge. The oil pump screen should be checked for clogging at about every 750 to 1000 hours of operation. It should be washed in a solvent before it is replaced. The crankcase breather element should be cleaned when the oil is changed to prevent clogging and reduce burned gases in the engine.

Transparency No. 3

c. Oil Lubricating Valves and Gauges - The oil gauge should be checked before checking the oil filter. If the filter is very dirty the pressure reading will be low.

Some tractor engines have test locations in the block so that a master gauge may be used to take a pressure reading. Any time the oil pressure reading goes below normal, a pressure reading should be taken and compared with the engine specifications.

Oil pressure may be increased by putting more tension on the lubricating valve spring or decreasing the spring's tension. If the valve plug is not adjusted, a washer may be added or removed from between the spring and plug.

It is important that the filter bypass valve be cleaned periodically. Check the valve head and seat for wear, and wipe the bore clean before replacing. The engine oil pressure should be checked before replacing the valve.

Defective pressure gauges should be replaced with an accurate gauge. A mechanical gauge may be checked by loosening the line a few turns at the block, starting the engine, and permitting the oil to drip out at the loose connection. If no oil leaks at the connection there is little or nor pressure in the lubricating system.

Electrical indicating systems should be checked periodically for poor grounding and poor connections.

8. Transmission Systems

Transparency No. 4a

a. It is recommended that gear-case lubricants be changed at least once per year. Some tractor manufacturers recommend that transmission lubricants be changed every 1000 hours of operation if the tractor is operating under normal conditions.

b. Many of the newer model tractors are equipped with transmission oil pumps. Most of the older model tractors used a splash system for getting oil to all gears. Regardless of the type system used, the oil oxidizes, thickens, additives become depleted, and abrasive contaminants collect in the lubricant. Therefore, the lubricant must be drained and the transmission refilled with new lubricant peridically.

c. The transmission may be flushed with kerosene or diesel fuel before refilling it with transmission lubricant. After the old oil is removed, the transmission should be filled to the proper oil level. The tractor should be driven for a few minutes before removing the flushing lubricant.

d. Only lubricants specified by the manufacturer should be used in the transmission. Some manufacturers recommend a multifunctional fluid to lubricate the transmission, hydraulic system power steering, power brakes, and final drive unit.

9. Lubricating Wheel Bearings

Transparencies Nos. 4b and 4c

The front wheel bearings should receive special lubrication care even though they are protected from dirt and other contaminants by seals. The rear wheel bearings are usually lubricated from the lubricant carried in the differential or final drive. If the wheels are equipped with grease fittings, they may be lubricated daily or as recommended by the Operator's Manual.

Once or twice each year the front wheels should be removed and bearings and hubs washed with kerosene. All the old grease must be removed before repacking and reassembling the wheel. Old seals should be replaced. Multi-purpose or special bearing grease is used on the front wheels. Check bearings for damage before replacing.

10. Lubricating Miscellaneous Parts

Transparency No. 5

a. Usually two or three strokes applied to a grease fitting (jet) with a grease gun will supply sufficient grease to lubricate the part and flush out a portion of the

old grease. Some grease areas are completely sealed; therefore, grease cannot be flushed out. The tractor parts that may be equipped with grease fittings are:

Clutch and Brake Pedals
Three-point Hitch
Rear Axle Bearings
Front Axle
Drive Housing
Clutch Relief Bearings
Steering Shaft

b. Some generators are equipped with oil cups at the drive and commutator ends. Fill these cups periodically when the engine is stopped.

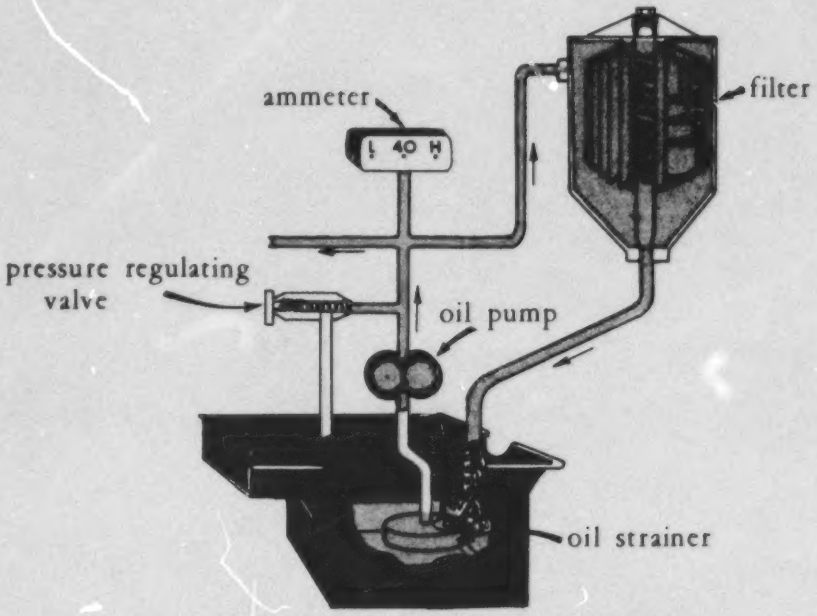
References:

Stone, Archie A. and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, NY, 1967

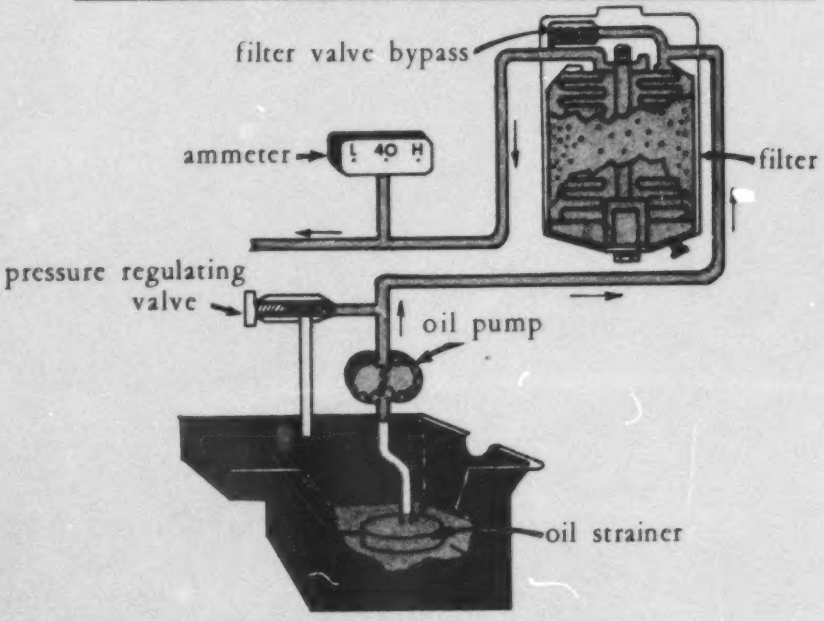
"Fundamentals of Service Engines", Deere and Company, Moline, IL, 1972

"Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

LUBRICATION

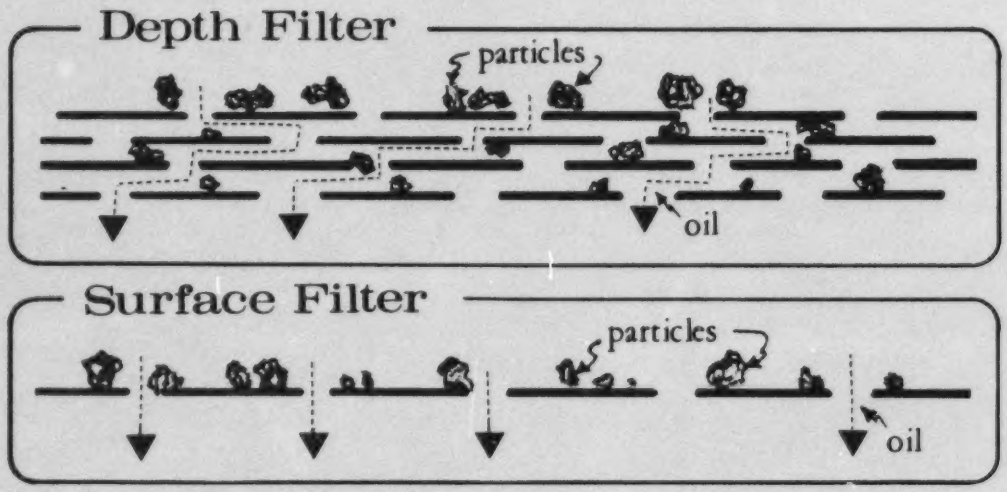


BYPASS FILTRATION SYSTEM



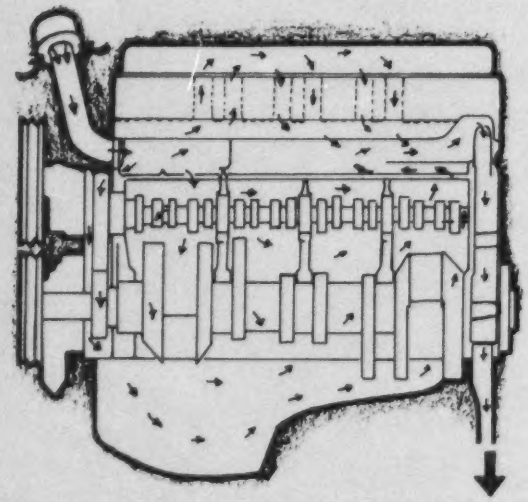
FULL FLOW FILTRATION SYSTEM

LUBRICATION

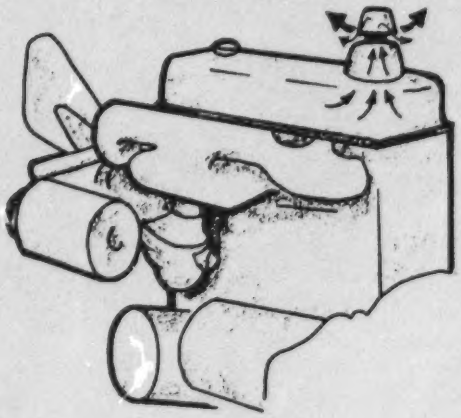


VENTILATION

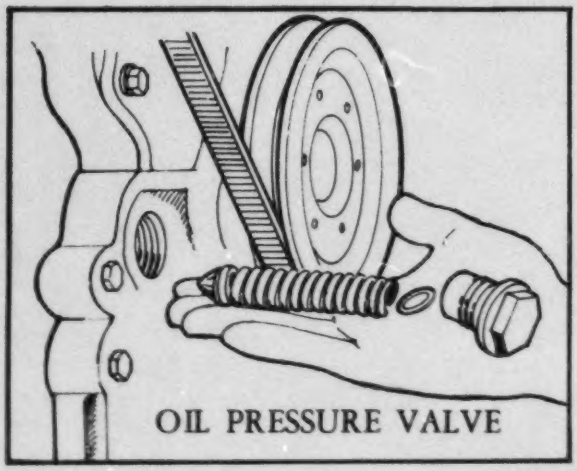
Fresh air enters cap and passes out vent tube



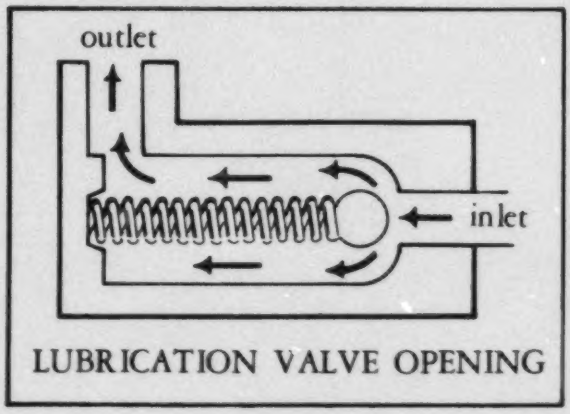
Air forced out cap in older model tractors



DRAINING OIL FROM FILTER & CRANKCASE

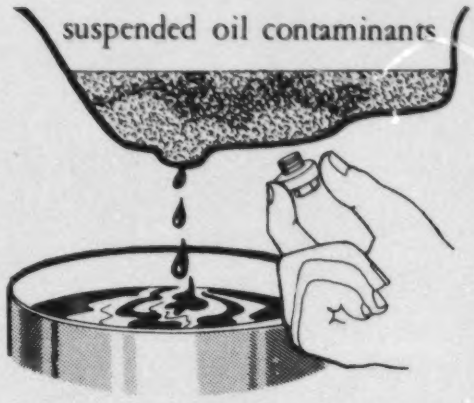


OIL PRESSURE VALVE

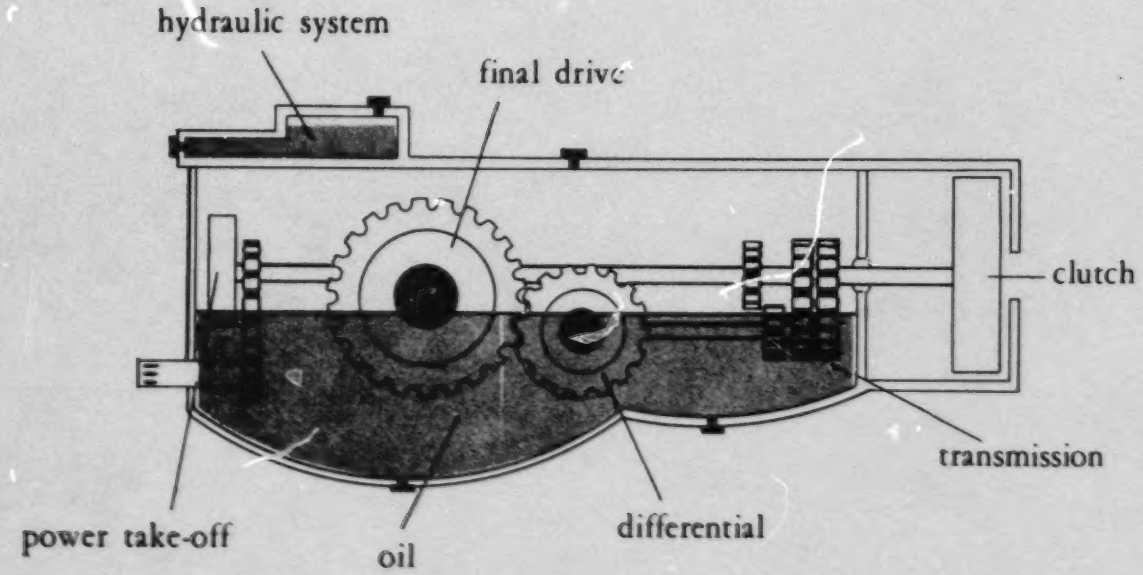


LUBRICATION VALVE OPENING

REPLACING FILTER ELEMENT

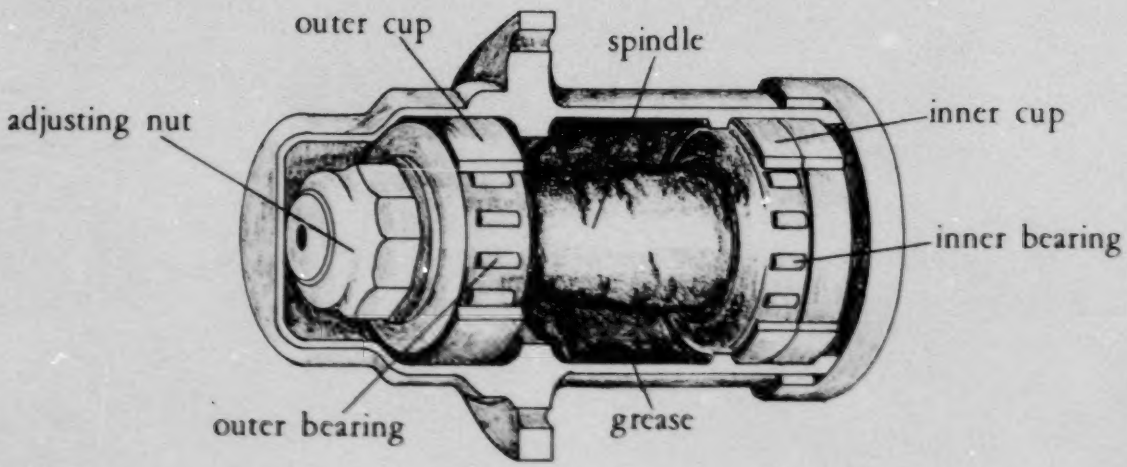


LUBRICATION



DRIVE MECHANISM

FRONT WHEEL LUBRICATION

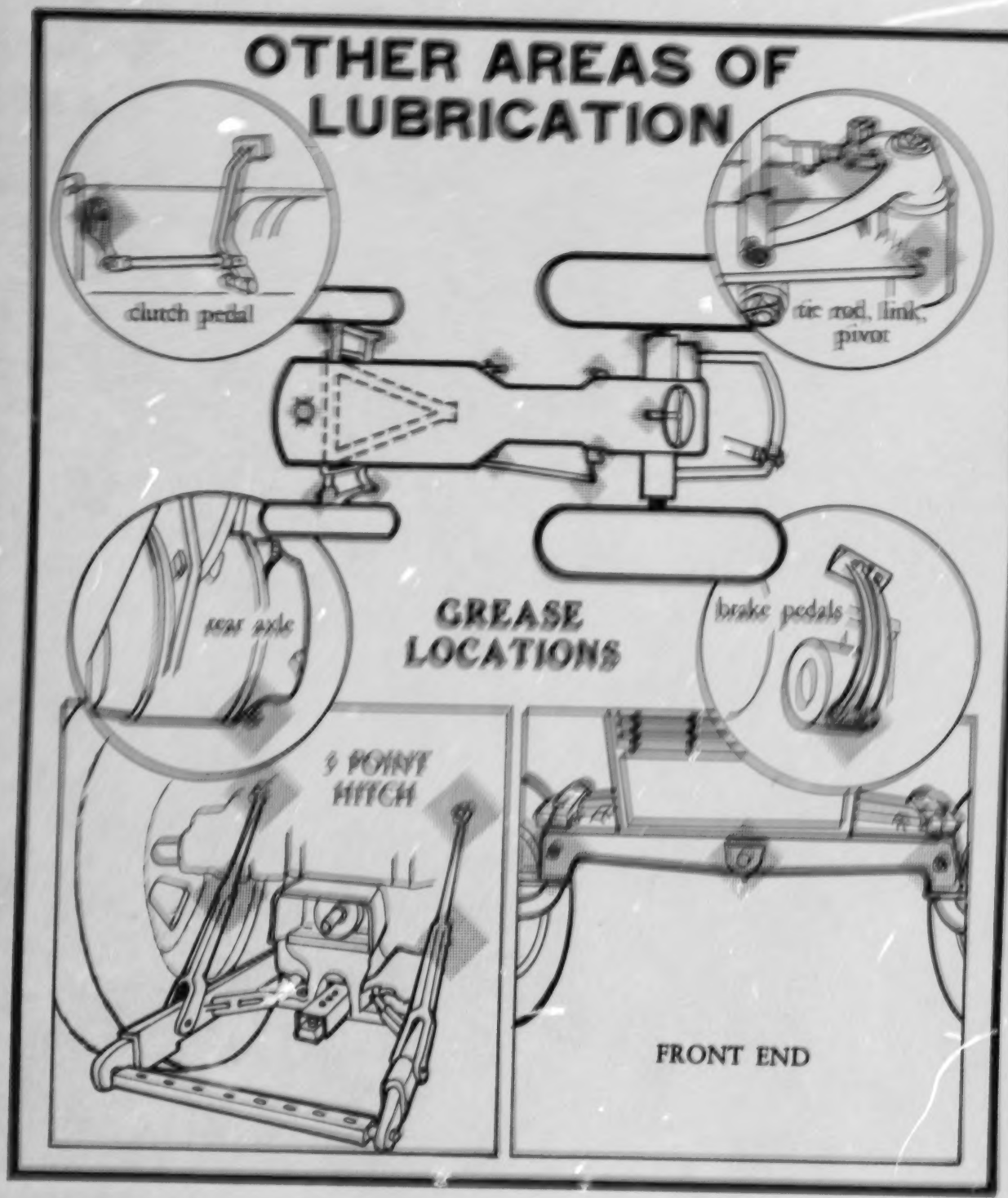


LUBRICATION

WORKING GREASE INTO BEARING

CLEANING INNER BEARING

OTHER AREAS OF LUBRICATION



FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 5: Power Train

Suggested Procedure and Activities: A side cut-away view of a tractor power train will be helpful in explaining its functions and maintenance.

1. The Purpose and Major Parts of a Power Train

The power supplied by the tractor engine must be transferred to the wheels and tires with the ground or other surface. The engine power may be transmitted by gears, drive belts, and by hydraulic systems.

The clutch, transmission, differential, final drive, and their component parts make up the power train system found in a tractor.

2. The Purpose of the Clutch

Transparencies Nos. 1 and 2

The clutch is commonly recognized as the first part of the power train system. Its main function is to connect the engine with the transmission which starts the machine or special parts of the machine moving. It also disconnects the engine from the transmission, permitting the machine or tractor engine to idle or run free of load. The clutch mechanism allows a load to be applied gradually to the machine.

The clutch uses friction to transmit power to the machine. The friction is caused by touching two surfaces that are made of steel and asbestos or some other material that will withstand heat and wear caused mainly by friction.

If two disks are mounted on two separate shafts opposite each other, one may rotate while the other remains motionless, that is, if the disks do not touch each other. However, as soon as the two disks come in contact with each other, both shafts will turn as a single unit. A disk clutch operates by this principle, two rough surfaces touching each other.

The clutch operates in the following manner:

Clutch Engaged - The clutch disk is clamped against the flywheel by clutch springs located in the pressure plate. As the clutch pedal is released, the

clutch levers are released by the release bearings. This action causes the clutch disk to engage with the flywheel.

Clutch Disengaged - When the clutch pedal is forced down or in, the disk is separated from the flywheel due to the clamping action on the pressure plate being released. The release bearing moves to the right and depresses the clutch levers, and this removes the pressure from the pressure plate.

Clutches are classified according to the way they are operated and according to the clutch assembly. The most common clutch found on farm tractors is the foot operated single disk type. Some of the larger tractors have hand operated clutches. Some larger farm tractors have multiple disk clutches. Multiple disk clutches are of two types: the dry-type and the wet-type. The wet-type clutch operates in either an oil bath or spray.

3. The Purpose of the Transmission

A transmission made up of several gear ratios is needed in a tractor in order for it to develop sufficient pulling power or torque to pull heavy loads. This system of gears is constructed so that the pulling power may be increased, the speed may be varied, and the direction of the tractor may be changed.

a. The gear case of a conventional tractor transmission system contains a set of two shafts. This conventional gear unit usually provides three or four forward speeds and one reverse speed. Many of the more modern tractors are equipped with a gear that changes the direction of the input shaft. This change in shaft rotation will give several speeds forward and several speeds in reverse.

b. Different manufacturers use different types of torque systems to permit shifting gears down without using the clutch. Two of the most common torque methods used are:

Torque Amplifier - This is a gear mechanism which reduces the forward speed of the tractor. It is operated by a gear lever. Torque is a motion or action that produces rotation. It is meshed in with the entire gear system.

Hydraulic Torque - Converter - A torque - converter is a turbine device with a rotary pump that increases torque by hydraulic action as the speed is reduced. It is located ahead of the transmission system; therefore, this type gear system is known as the torque - converter transmission.

Transparency No. 3

c. The three major types of mechanical transmissions are as follows:

Sliding Gear - This type of transmission has sliding spur gears mounted on two or more parallel shafts. The gears change the speed of the tractor by meshing with each other as they slide on the shaft.

Collar Shift - The gears are on parallel shafts, and they are in constant mesh. Sliding collars lock the free running gears to their shafts as the gears are shifted.

Synchromesh - The gears are in constant mesh in this transmission system. Gears do not clash when shifting if the speeds of mating parts are synchronized before they are meshed.

The most common mechanical system found on farm tractors is the sliding gear system. It is designed so that the input and output shafts are parallel or in line. The third shaft in this system is the reverse shaft.

Transparency No. 3

The path of power through the parallel system is as follows:

The forward speed of the tractor is changed by the movement of the two sliding gears on the output shaft. Gear C turns freely on this shaft. Gears on the input and reverse shafts are fixed. Engaging the different gears determines the speed and direction of tractor movement.

Gears Engage	Gear and Shift Location
A and F	First or Low
B and E	Second
B and C	Third or High
A and H	Reverse
D and E, completely disengages	Neutral

4. The Purpose of the Differential

The differential drive is divided into two parts which are driven by a cluster of small gears. The differential permits one rear wheel to turn slower than the other on a turn, and it allows one wheel to spin while the other wheel may not. The differential is a compensating mechanism that allows each wheel to propel its own load even though the tractor is not driven in a straight line.

Transparencies 4a and 4b

The ring gear (large gear) is driven by the pinion gear. Power is transmitted from the engine through the clutch to the transmission, and from the transmission through the spline shaft and beveled pinion gear to the differential.

When both wheels are operating at the same rate of speed, the four pinion gears rotate as a unit in the same direction as the ring gear and the two side gears. If the tractor turns right or left, each of the four beveled pinion gears rotates allowing one wheel to turn at a more rapid rate than the other.

5. The Purpose of the Final Drive

Transparency No. 5

A final drive on a tractor is used to reduce engine speed before it is applied to the rear axle. The final drive is located on some tractors in the same case as the transmission and differential, but on most tractors it is a separate unit. Some late model tractors use planetary gears (planet ring and planet gears rotating around sun gears on final drive shaft) in place of spur gears.

The two major final drives that are found on tractors are:

a. Pinion Drives - The power is transmitted to the rear wheels through pinion gears. Reduced speed caused by the pinion and spur gear hook up increases torque to the rear wheels.

b. Planetary Drives - Engine power is received from the differential as in the pinion drive and transmitted to the final drive shaft and sun gear. Planet pinion gears are meshed with the sun gear and gear ring. This gear unit functions similarly to the pinion drive, in that engine speed is reduced and torque is increased to the rear wheels.

6. Maintenance of Clutches

The most important step to follow in servicing the tractor clutch is to use the operator's manual as a service guide. The kind of adjustment and lubrication of a clutch depends on the type of clutch.

Maintenance practices for friction type clutches are as follows:

Transparency No. 2

a. Many foot and hand operated clutches have grease fittings for lubricating either a throw - out or pilot bearing. One or two strokes with a grease gun will usually be sufficient amount of grease for many hours of operation. Over greasing may cause clutch slippage.

b. Check the clutch pedal free travel. The free movement may be between 1/2 inch to 2 1/2 inches. This is the distance a pedal can be depressed from its stationary position until it meets resistance. Adjustment locations are usually found on the throw - out rod, adjusting stud on the

housing and base of the foot pedal.

c. Adjust the over - center or hand clutch by loosening the lock pin inside the clutch housing and turning the collar to the right to compensate for wear. Replace the pin and the housing cover.

d. To properly maintain a wet - type clutch: check the oil level, oil seals, and replace any damaged seal; and check oil circulation.

e. To reduce clutch wear, remove the foot from the pedal on a foot operated clutch and remove the hand from a hand operated clutch. If the clutch is allowed to slip due to partial engagement it will get hot and wear more rapidly.

7. Maintaining the Transmission, Differential, and Final Drive

Most tractor transmissions, differentials, and final drives require little maintenance other than lubrication. It is important that the gear teeth and bearings be protected at all times with a continuous supply of clean lubricant to prevent wear.

Maintenance practices are as follows:

Transparencies Nos. 3, 4, and 5

a. Clean the area where the oil level is to be checked to avoid the entry of dirt or other contaminants into the gear case.

b. If the tractor has more than one compartment in the gear case, each gear case drain plug should be removed to remove oil from each drive mechanism.

c. Replace the gear case lubricant with the proper grade of oil as recommended by the manufacturer. The lubricant should be drained after a period of operation so that the warm oil will assure complete drainage.

d. If the tractor gear case is equipped with filter, it should be replaced at the time the lubricant is removed.

e. Air breathers that are located in the breather cap or on the gear case should be checked and cleaned periodically.

f. Check for oil leaks around filters, gaskets, and seals. Replace leaking seals and replace gaskets if necessary or tighten bolts around gaskets.

References:

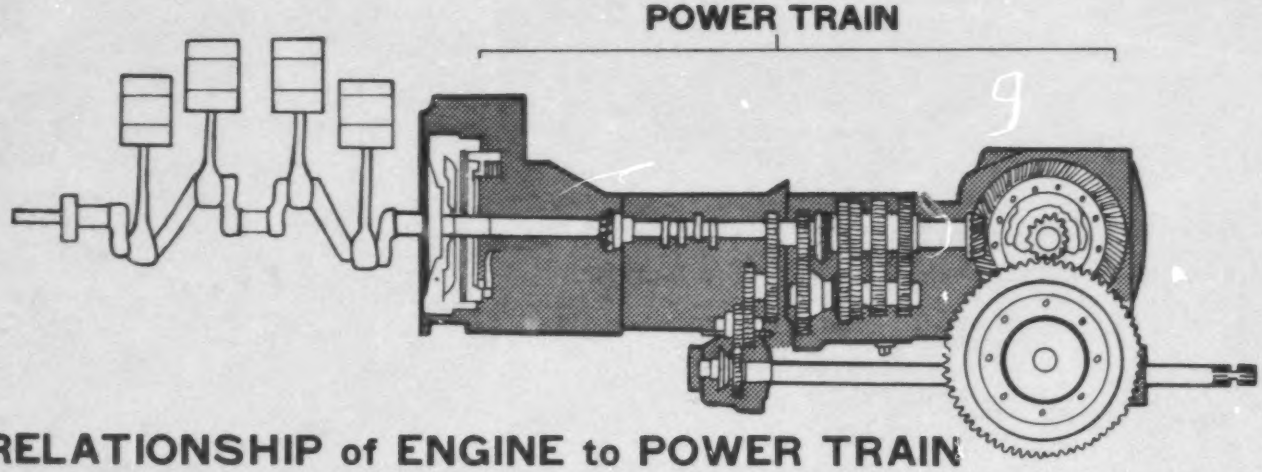
Promersberger, William J. and others, Modern Farm Power, Prentice - Hall, Inc., Englewood Cliffs, NJ, 1971

Stone, Archie A., and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, NY, 1976

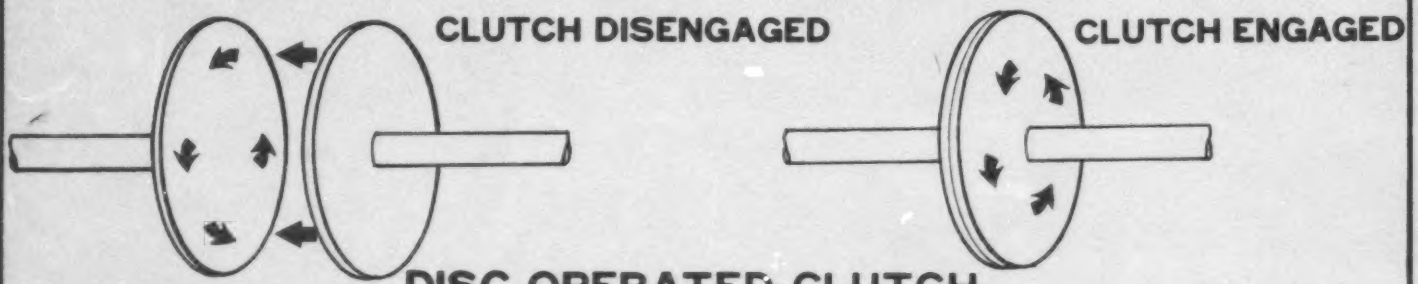
"Fundamentals of Service - Power Trains", Deere and Company, Moline, IL, 1972

"Tractor Maintenance - Principles and Practices", American Association for Vocational Instructional Materials, Athens, GA, 1975

POWER TRAIN



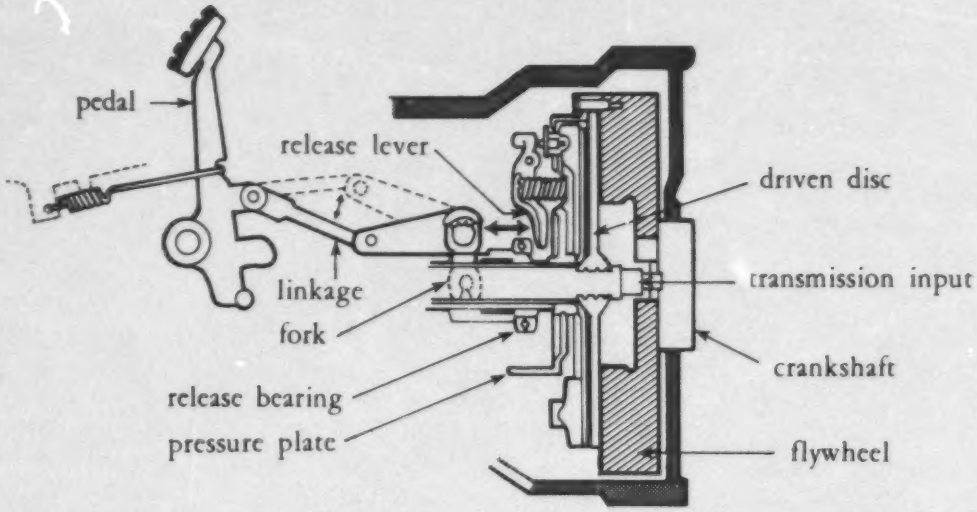
RELATIONSHIP of ENGINE to POWER TRAIN



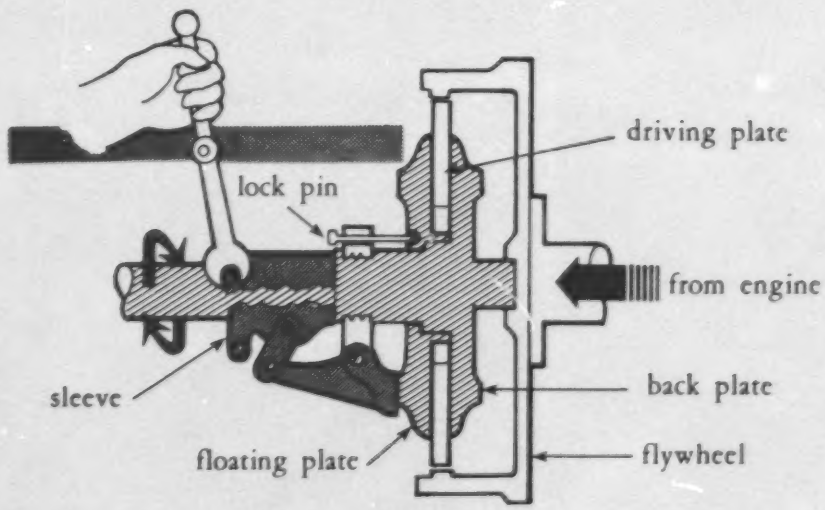
DISC OPERATED CLUTCH

DISC & PLATE CLUTCH ASSEMBLIES

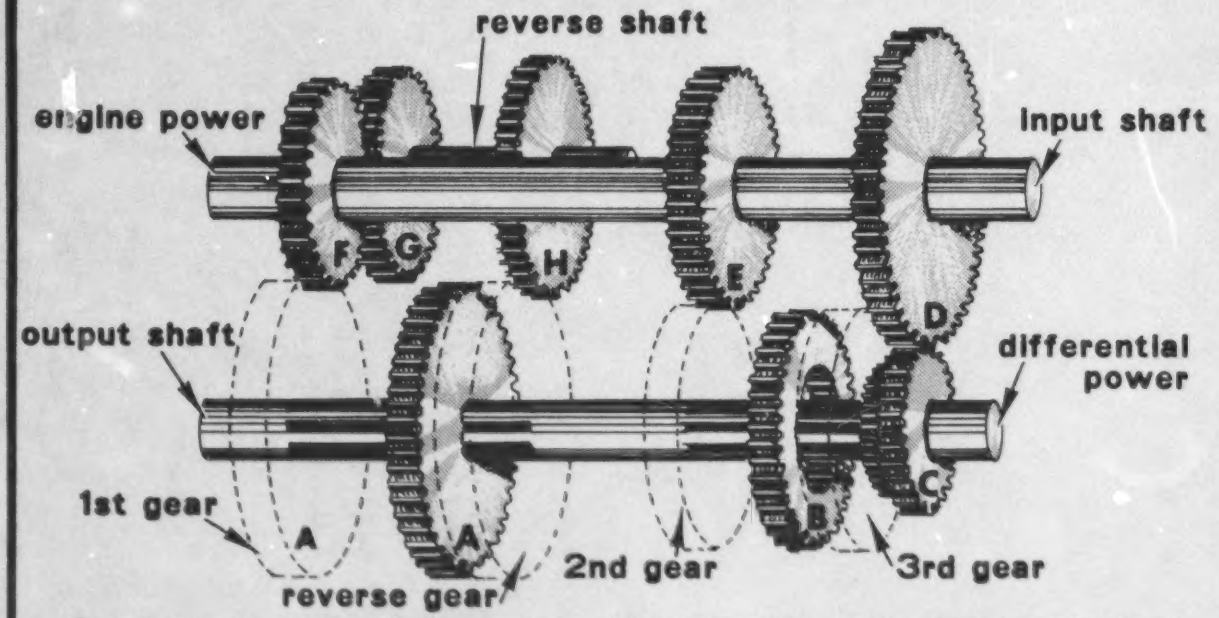
DRY TYPE DISC CLUTCH & LINKAGE



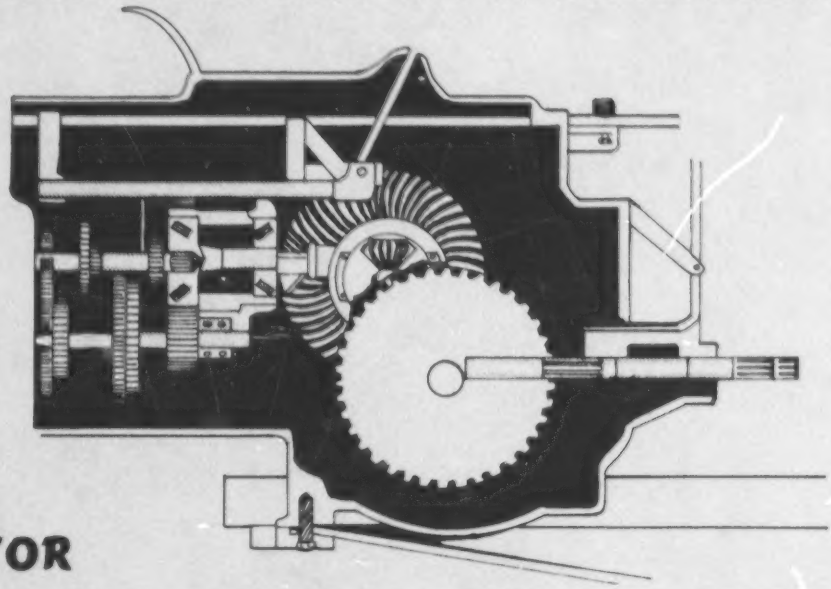
HAND OPERATED PLATE CLUTCH



POWER TRAIN

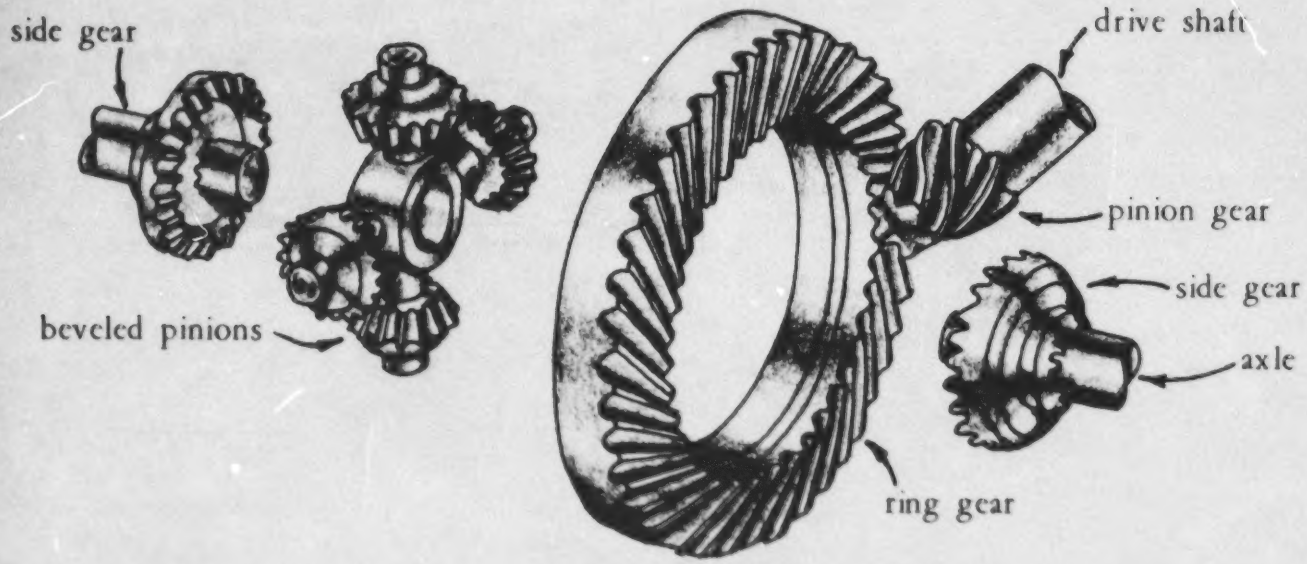


PARALLEL SHAFT SLIDING GEAR TRANSMISSION



TRACTOR
TRANSMISSION DIFFERENTIAL AND FINAL DRIVE

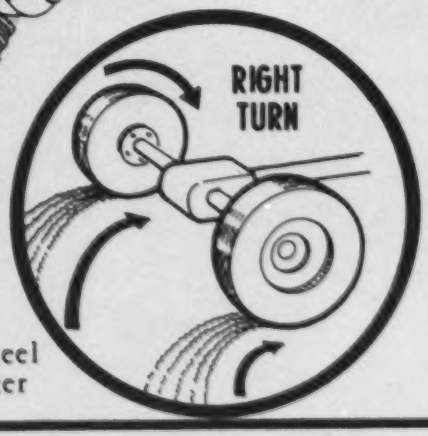
POWER TRAIN



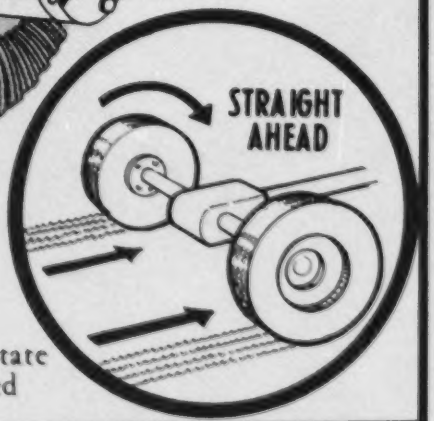
DIFFERENTIAL

POWER TRAIN

GEAR & WHEEL MOVEMENT

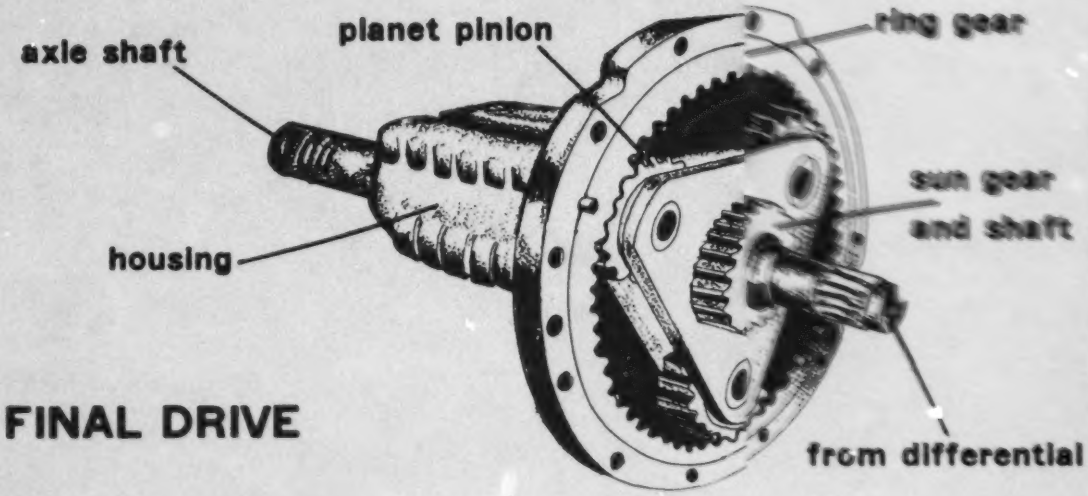


Outside wheel rotates faster

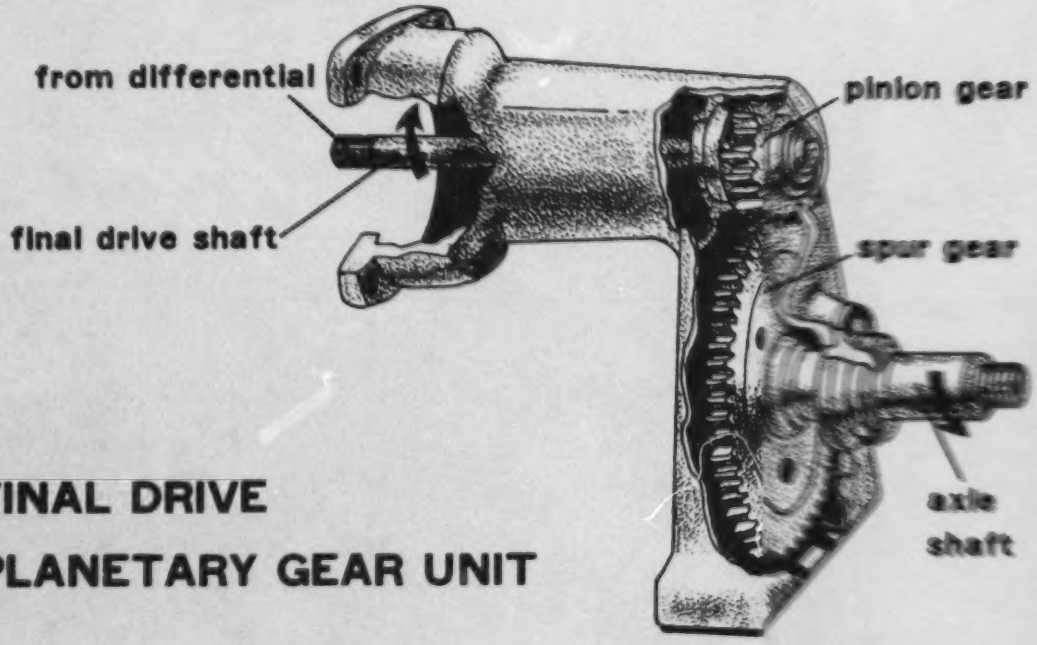


Both wheels rotate at same speed

POWER TRAIN



FINAL DRIVE



FINAL DRIVE
PLANETARY GEAR UNIT

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 6: Braking

Suggested Procedure and Activities: Parts of the brake mechanism and brake models will be helpful as teaching aids during the class discussion.

1. Purpose of Brakes on a Tractor

The major purposes of brakes on a tractor are similar to the purposes of brakes on an automobile, with one exception, and that is turning the tractor. Brakes aid in maneuvering the tractor, and they serve as a safety device. The purposes are: slowing, stopping, and turning the tractor.

Most modern farm tractors can travel at a dangerous rate of speed if free of a load or pulling non-working equipment. Brakes are used to reduce the speed for making a turn or when approaching other traffic or objects. There are certain types of tractor jobs that require forward and reverse movement of the tractor and equipment. It is necessary that the tractor be stopped and started for this type of work. Stopping the movement of the machine, either for work or parking, may depend upon the frequent use of the braking system.

2. Factors Affecting the Use of Brakes

The tractor speed, the load it is pulling, and the surface it is traveling on are considered the chief factors that affect the use of the brakes. Other factors involved are:

a. Brake Conditions - Brakes that are severely worn or out of adjustment do not function properly.

b. Travel on Slopes - The tractor is assisted by gravity in making a stop if it is moving up a hill. If the tractor is traveling down a hill, gravity aids in the movement of it.

c. Tire Tread - Severely worn tires may require a different method of braking than new or good tires.

d. Pressure Applied on Brake - The force applied to the brake leverage may affect the function of the brake.

e. Braking Force of Engine - The engine is a braking force that is used any time the tractor is in motion. The engine and low transmission

gears may be used when traveling down a hill.

f. Turn - The number and degree of turns to be made in travel.

Transparencies Nos. 1 and 2

3. The Kinds of Brakes and How They Function

a. Shoe Brake - Shoe brakes are considered an interval expanding type mechanism. The two brake shoes are forced against the brake drum when the brake pedal is depressed. When the brakes are not in use, springs hold the brake shoes off the drums. In this system of braking the drums rotate around the brake shoes. The drums are mounted on either the differential or rear axle shaft.

b. Band Brakes - In this kind of brake unit, the lined brake band is pulled around the outside of the rotating drum. The drum is mounted to the differential shaft or on the axle shaft. One end is attached to the tractor frame. When pressure is applied to the brake pedal, the band tightens around the drum and stops the rear wheel movement.

c. Disc Brake - The discs are mounted on either the differential shaft or the rear axle shaft; therefore, they rotate when the tractor is in motion. There are two actuating discs in this braking system; they do not rotate very far due to blocks in the brake housing. These discs are forced apart by three steel balls that move out of their slots when the discs rotate a short distance opposite each other. The two outside discs are forced against the housing braking surface by the inside discs.

d. Mechanical Disc and Band Combination Brakes - The function of the brake parts are similar to the disc and band brake. When pressure is applied to the brake pedal, the brake band tightens around the drum, and at the same time the disc is forced against the brake housing surface. This combination brake is attached either to the axle shaft or differential shaft.

e. Hydraulic Disc Brake - The hydraulic brake system functions in the following manner:

The downward movement of the brake pedal closes the upper release valve and opens the lower pressure valve.

Hydraulic fluid pressure is forced from the pump brake shoe against the brake disc. The disc is forced against the stationary brake shoe; this slows or stops wheel movement.

The lower valve closes and the upper valve opens when the brake pedal is released. This action permits the pressure to be released and the fluid to flow back into the cylinder.

As the brake pistons move away from the brake disc, wheel move is freed and the brake disc is free to rotate with the axle movement.

The hydraulic disc brake is known as the "wet-disc" brake due to the shoes in an oil compartment. The oil is usually supplied by the transmission.

Transparencies Nos. 3a, 3b, and 4

4. Maintenance of Tractor Brakes

a. Usually it is advisable to free both rear wheels so that they may be rotated. A hoist or jacks may be used to clear the rear wheels from the ground.

b. If both brake pedals are on one side, they are usually locked together. Unlatch the brakes, make adjustments on lock brake first, but not so tightly that it will not latch. Adjustments are usually made on different types of brakes in the following manner:

Disc or Band Brakes - Loosen jam nut and adjust pull rod. There may be a brake rod with an adjustment at the yoke. In this case, the lock nut is loosened and the yoke is turned on the rod. Some disc brakes are adjusted by side adjusting screws.

Internal Shoe Brakes - The adjusting slot cover is removed and the star wheel is turned with a screwdriver or special star wheel tool. Tighten until there is drag, and release until there is little or no drag.

External Shoe Brake - This brake is adjusted by turning the adjusting screw between the brake and the housing. Tighten until there is drag, and release until there is no drag.

c. The second brake should be adjusted in the same manner as the first brake. The same amount of free travel should appear in the second adjustment as in the first adjustment.

Usually a brake is adjusted by shortening the linkage between the brake and pedal or by making the star wheel adjusting screw longer. The brake is tightened until there is a certain amount of free travel on the brake pedal. The distance of pedal free travel is specified in the operator's manual.

d. The brakes are checked for equalization by practicing the following steps:

Latch the two brakes together.

Start the engine and start the wheels turning by shifting into third gear.

Shift back into neutral and apply pressure to the brake pedal. Check the wheels to determine if they brake evenly.

e. The last step is to lower the tractor to the ground and check the brake by driving the tractor in third gear.

5. General Information About Brakes

Brakes should be checked and adjusted periodically. Well adjusted brakes may mean safer and more efficient use of the tractor and its equipment.

Farm tractor brakes are located on each rear wheel. If the brake pedals are on each side of the tractor, or both are located on one side and unlatched, the tractor can be turned sharply by braking the inside wheel.

Most farm tractor brakes are operated by foot pedals, but some tractors have hand brakes.

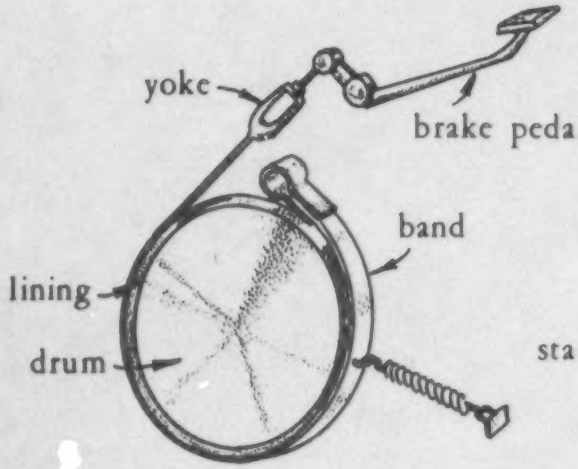
References:

Promersberger, William J. and others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971

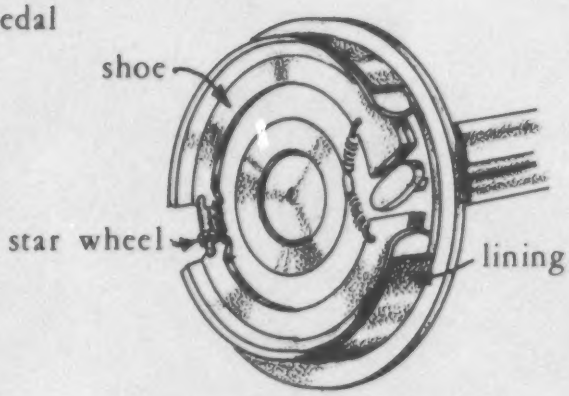
"Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, GA, 1975

"Farm Tractors - Basic Principles, Operation, and Maintenance", Humble Oil Company, Houston, TX, 1967

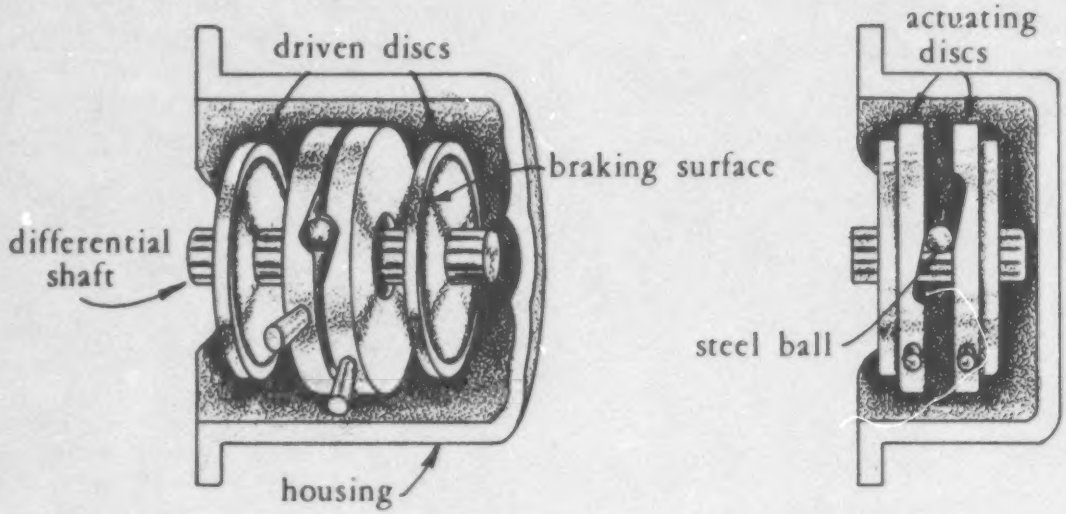
TRACTOR BRAKES



BAND BRAKE

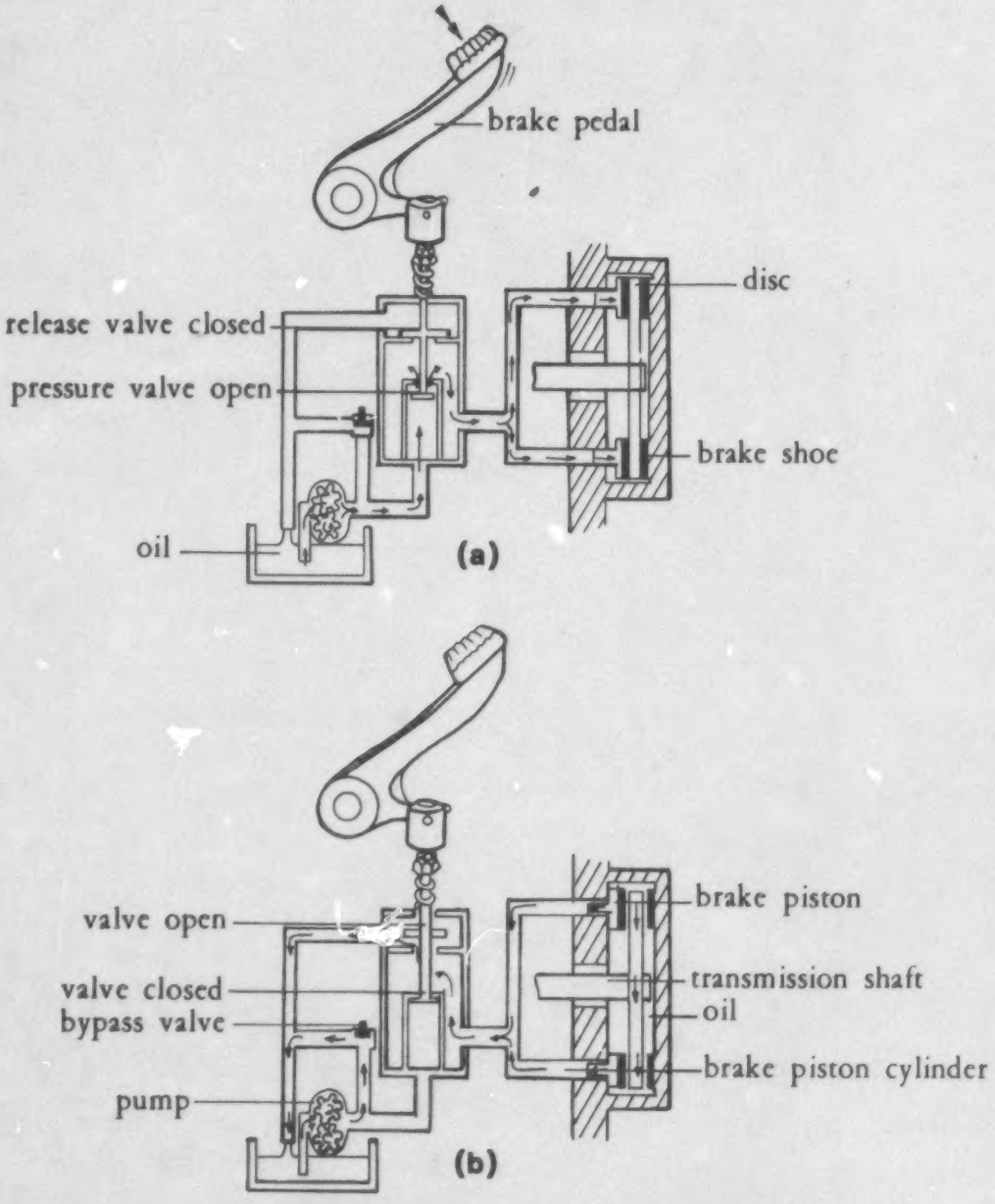


SHOE BRAKE



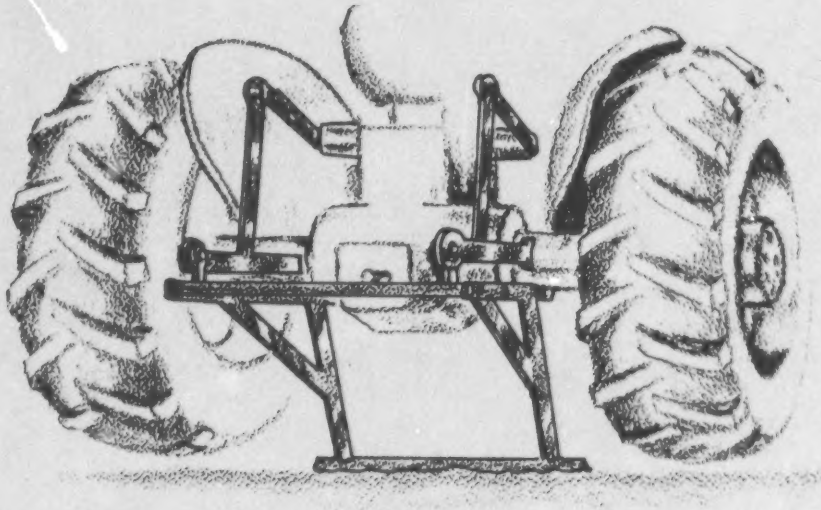
DISC BRAKE

TRACTOR BRAKES

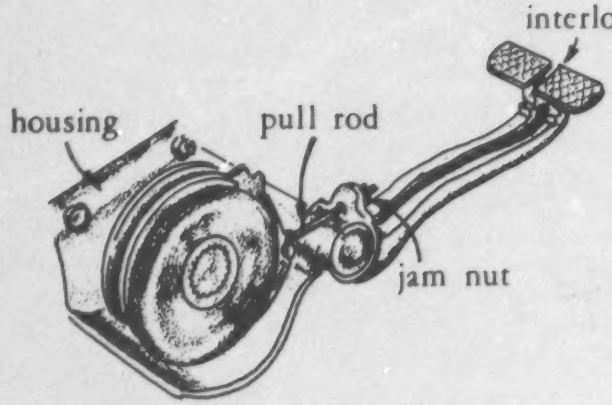


HYDRAULIC BRAKE OPERATION

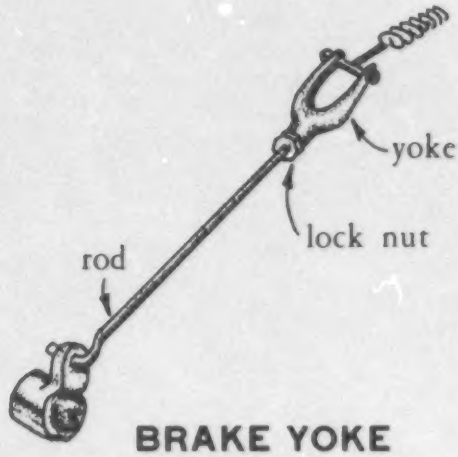
TRACTOR BRAKES



REAR WHEELS OFF GROUND

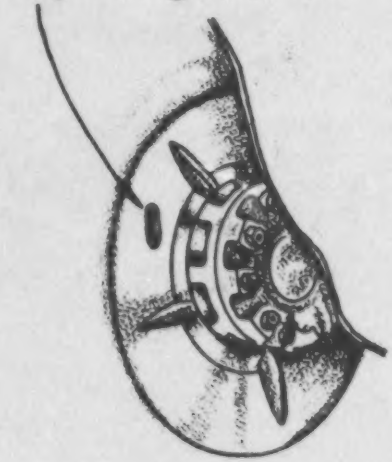


DISC BRAKES & PEDALS

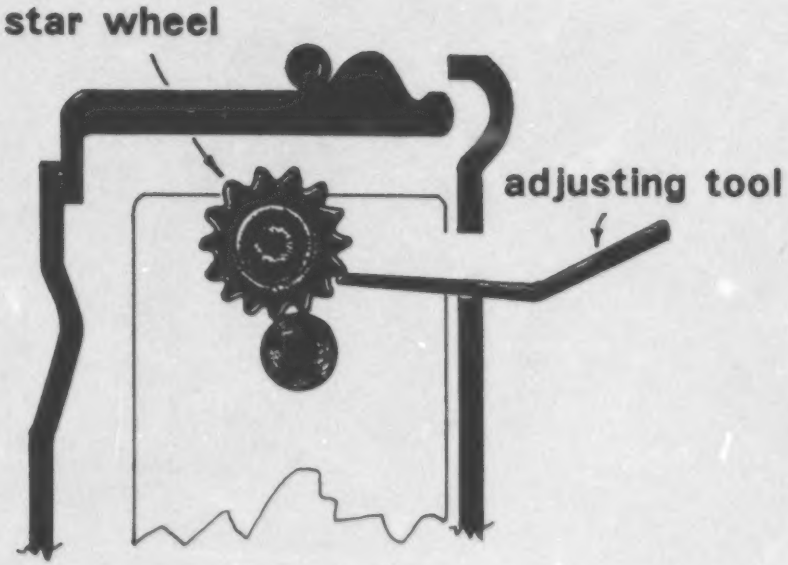


BRAKE YOKE ADJUSTMENT

TRACTOR BRAKES

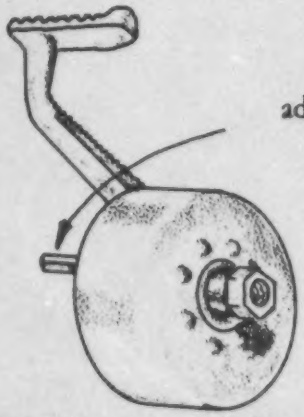


INTERNAL SHOE
BRAKE ADJUSTMENT



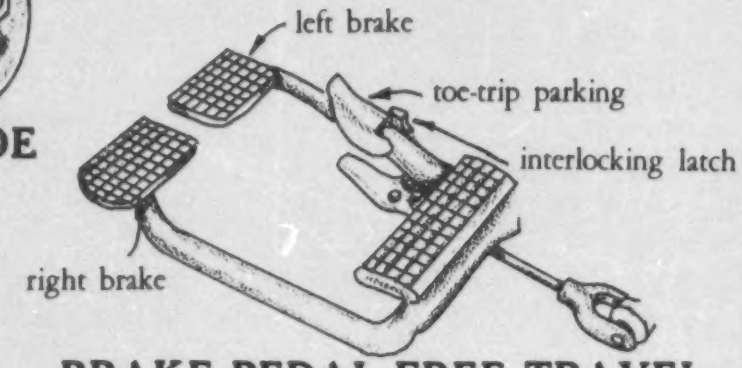
POSITION OF ADJUSTING TOOL

TRACTOR BRAKES

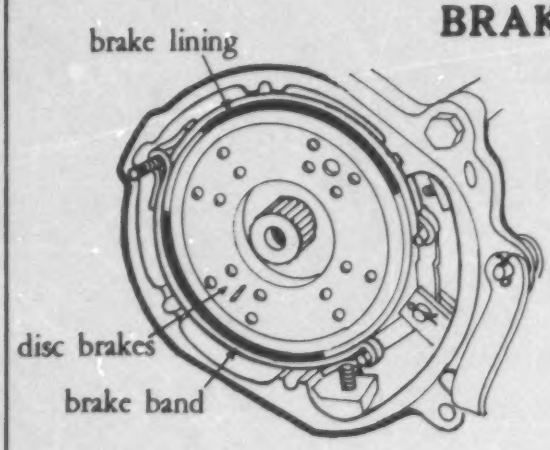


EXTERNAL SHOE BRAKE

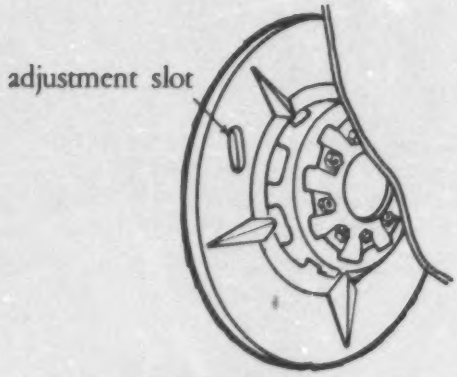
DISC BRAKE



BRAKE PEDAL FREE TRAVEL



COMBINATION BRAKE



INTERNAL SHOE BRAKE

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 7: Hydraulics

Suggested Procedure and Activities: After discussing the hydraulic system, a farm tractor may be used as a teaching aid in the laboratory. The visible parts of the system may be pointed out and discussed.

1. The Purpose of Hydraulic Systems on Farm Tractors

   Most farm tractors are equipped with some type of hydraulic system. Hydraulic controls make the tractor more versatile by raising, lowering, and controlling the depth of equipment. The hydraulic system is also used for operating the tractor "controls".

   Hydraulic remote controls are used for operating power shovels, dozer blades, post hole diggers, manure loaders, hay rakes, fork lifts, disk harrows, plows, mowers, sprayers, and many other types of equipment.

2. The Function of the Basic Parts of a Hydraulic System

   a. Pump - The major function of the pump is to develop pressure which moves the oil to the cylinder. The most common types of pumps are: piston, gear, rotor, and vane. The gear and rotor pumps function similarly to the oil pumps of this type.

   b. Cylinder and Piston - Hydraulic force is transmitted to the leverage of the equipment or machine by the proper function of these two parts (cylinder and piston). The hydraulic power of the oil is converted into mechanical power by the operation of these parts.

   c. Oil Reservoir or Oil Sump - Oil is stored for the hydraulic system's use in the reservoir or sump. This storage unit may be located above or below the hydraulic oil pump.

   d. Oil Lines - Oil lines handle the flow of oil from the reservoir to the pump; from the pump to the valves; from the valves to the cylinder; and from the cylinder to the filter where it re-enters the reservoir.

   e. Control Valves - These valves regulate pressure and direct the flow of oil to and from the cylinder by opening and closing oil passages. Usually the control valves are operated by hand levers.

f. Check Valves - These valves permit oil to flow in one direction. They hold the oil in the reservoir between cylinder strokes.

3. Two Major Types of Hydraulic Systems

Transparencies Nos. 1 and 2

The two most common types of hydraulic systems found on farm tractors are the open-center and closed-center systems. A comparison of the two systems is as follows:

Open - Center System - The hydraulic oil pumps operate any time the engine is running. Oil flows from the reservoir to the pump, through the valve, and back to the reservoir when the system is in neutral. The oil is diverted by a control valve when the system is used for work.

Closed -Center System - The oil is maintained in the system at full pressure. The pump does not function when the system is in neutral unless the pressure drops below full system pressure. The control valve stops the flow of oil from the pump when the pressure reaches the maximum limit. The closed system has been replacing the open-center system since the demand has increased for power brakes, power steering, and more different types of remote control cylinders.

The main advantage of the closed-center system is that more power is available for many other uses due to using a pump of smaller capacity to supply oil to the system. Where an accumulator is used in this system, a reserve of oil pressure is maintained to do hydraulic work.

Many modern farm tractors use up to 40 percent of their power for operating the hydraulic system; therefore, it is important that the pump shuts off to save engine power when the hydraulic are not being used.

4. Transmitting Power Through the Principles of Hydraulics

a. Tractor Hydraulics Systems - These systems use oil to transmit power. Oil is similar to other liquids in that it cannot be compressed or forced into an area smaller than the area it originally occupied. Oil is a liquid; therefore, it takes the shape of its container. Most tractor hydraulic oil is a light grade of motor oil. This oil contain anti-rust, anti-foam, and anti-wear additives. These additives are desirable properties in hydraulic fluids.

Transparency No. 3

b. Principles of Tractor Hydraulic Systems - If a container is filled with a liquid, the pressure becomes the same against the walls of the container.

For example, if a bottle is filled with a liquid and a cork is inserted in the neck and pressed downward, the pressure is the same on the inside of the bottle. Another example of liquids transmitting pressure in all directions is:

If the cylinders are connected by a tube and partially filled, the liquid will be at the same level in both cylinders. A one-pound weight inserted in each cylinder and placed on top of the liquid will not change the level.

An example of increases in work force is as follows:

Two cylinders of different sizes are joined together by a tube. One cylinder has an area of one square inch and the other ten square inches. If a one-pound piston is placed in the small cylinder it will support a ten-pound piston in the large cylinder. If no piston or weight is used, the liquid will remain at the same level in both cylinders.

5. How Hydraulic Systems Operate

Transparencies Nos. 4 and 5

a. Hydraulic System in Neutral - The oil is forced past the control valves to the oil filter and back into the reservoir.

The piston is held stationary in the cylinder by oil that is trapped on both sides of it by closed control valves.

b. Hydraulic System Lifting Equipment - The pump forces oil against one end of the cylinder to raise equipment. As the control lever is pushed forward, the spool valve moves to one side, opening the passage for the pressure oil to enter the cylinder at the top of the piston. The other control valve shifts the spool to one side, opening the passage for oil to enter the reservoir or sump.

When an implement or piece of equipment is raised, the cylinder is extended in length due to the outward movement of the piston rod.

c. Equipment Lowered by the Hydraulic System - To lower equipment or an implement, the control lever is pulled back. This lever action moves the spool valve to the other side in the control unit, freeing another ball valve and opening the main passage to the lower end of the piston. The direction of oil flow is reversed from that of raising equipment with the hydraulic system.

Transparency No. 6

d. Remote Control - Equipment that is not mounted on the tractor is controlled

by a hydraulic system that is connected to the tractor by flexible hoses. This system is operated by a control lever that actuates the control valve and sends oil to the cylinder. The cylinder is usually mounted on the equipment.

6. Maintenance of the Hydraulic System

The two most important points for the tractor operator to remember in maintaining the hydraulic system are proper operation and the use of a good grade of clean oil.

Transparency No. 6

a. Hydraulic systems are damaged by the following causes:

Dirty oil
Use of oil not recommended for the system
Lack of oil in the reservoir
Loose intake lines
Oil filters clogged or dirty
Too much pressure in the system
Too much heat in the system
Operating the system too fast

b. Some important maintenance practices to observe are:

Store new oil in a clean location and use only clean funnds and containers with fine mesh screen when refilling reservoir.

Any connection on the system that may allow dirt and other foreign particles to enter the oil should be wiped clean before removing.

The work area and tools must be clean before removing component parts of the system that may contaminate the oil if exposed to dirt or foreign particles.

The system should be checked for internal and external leaks. The symptom of internal leakage is sluggish action. The system should be tested by a technician if this condition is present. External leakage including pinholes in hoses, can be detected easily and corrected.

The hydraulic system may be drained and flushed periodically as recommended by the operator's manual. It is usually not necessary to flush the system each time the oil is changed.

After the system has been refilled with new oil, it should be operated four or five times through a complete work cycle before bleeding air from it. Oil

should be added to the proper level before putting the machine to work.

Overheating is an operational hazard in many hydraulic systems. Overheating breaks down the oil, causes varnish deposits, and reduces efficiency of the unit. Some maintenance practices to either prevent or reduce overheating are:

Keep the oil at the proper level in the reservoir.

Keep the lines, reservoir, and cooler free of dirt and materials that reduce oil flow or contaminate the oil.

Keep the relief valves operating properly by making adjustments periodically.

References:

Promersberger, William J. and others, Modern Farm Power, Prentice-Hall Inc., Englewood Cliffs, NJ, 1971

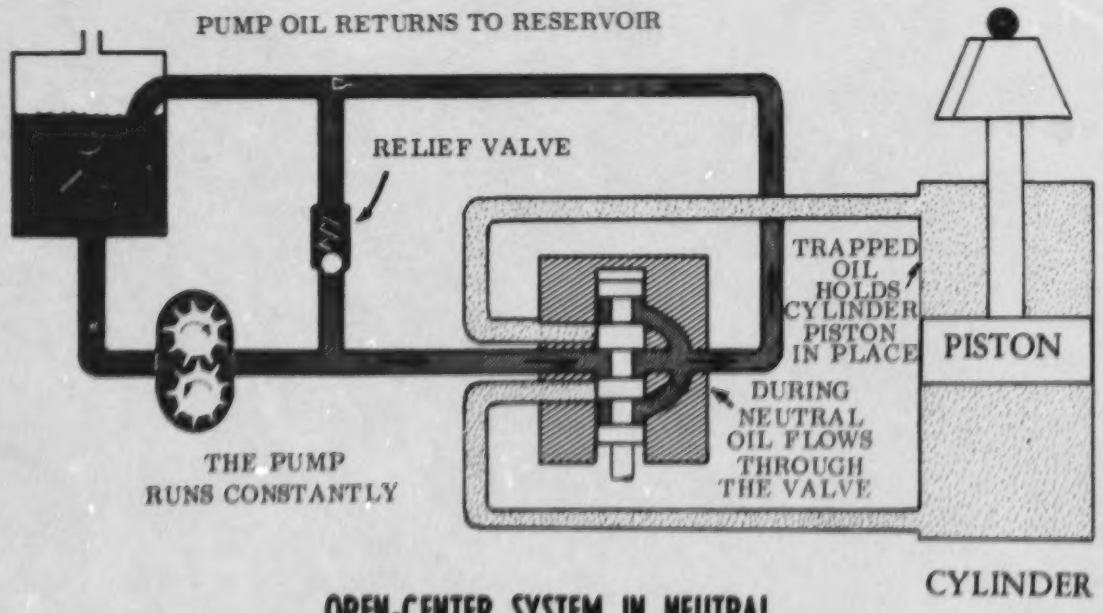
Stone, Archie A. and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, NY, 1967

"Fundamentals of Service Hydraulics", Deere and Company, Moline, IL, 1972

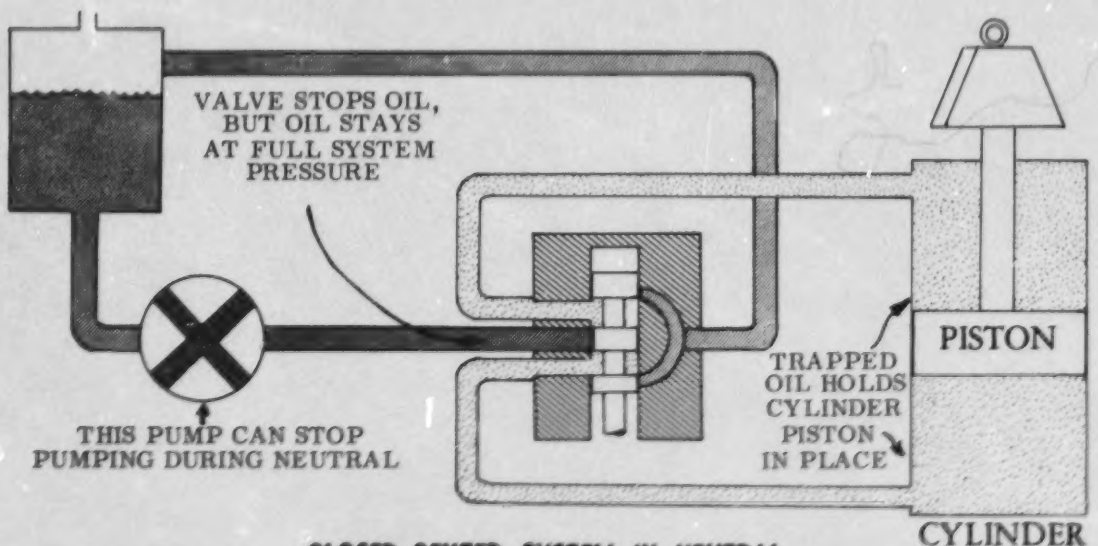
"Farm Tractors - Basic Principles, Operation, and Maintenance", Humble Oil Company, Houston, TX 1967

"Tractor Maintenance, Principles, and Procedures", American Association for Vocational Instructional Materials, Athens, GA, 1975

HYDRAULICS

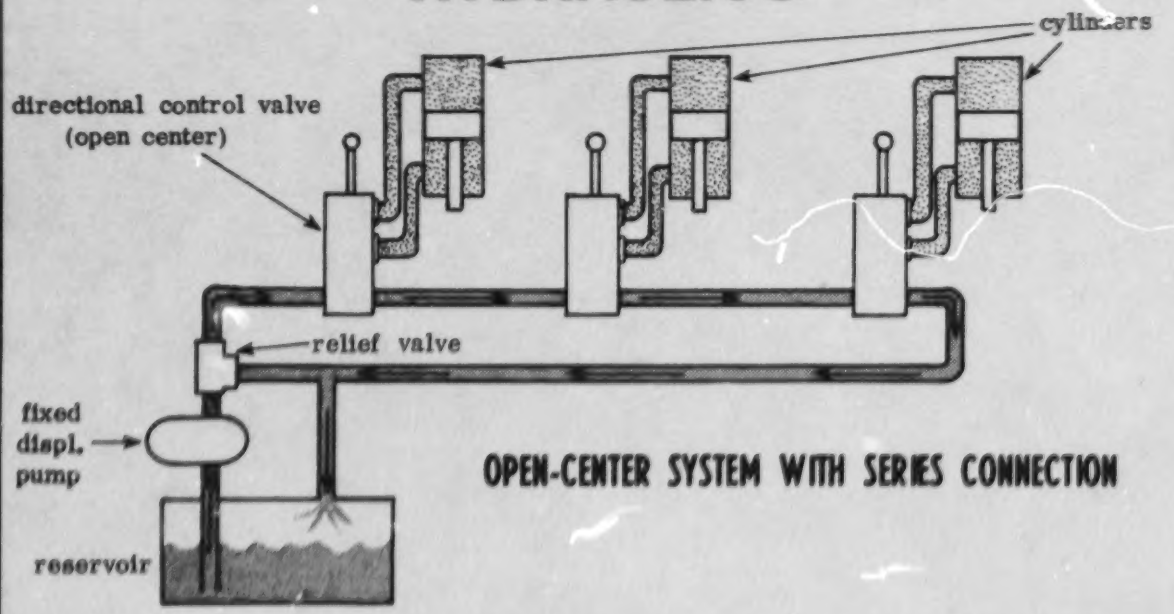


OPEN-CENTER SYSTEM IN NEUTRAL

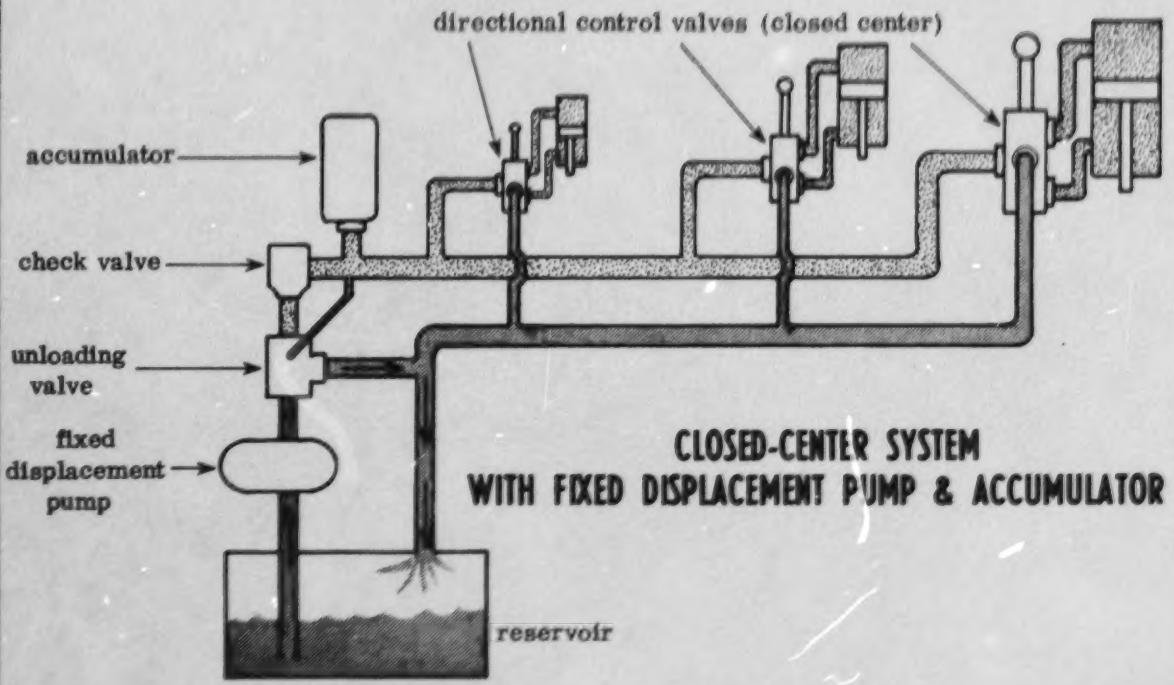

VALVE STOPS OIL, BUT OIL STAYS AT FULL SYSTEM PRESSURE
PISTON
TRAPPED OIL HOLDS CYLINDER PISTON IN PLACE
THIS PUMP CAN STOP PUMPING DURING NEUTRAL
CYLINDER

CLOSED-CENTER SYSTEM IN NEUTRAL

HYDRAULICS

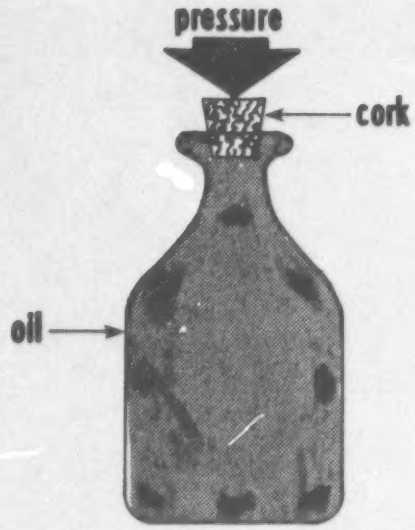


OPEN-CENTER SYSTEM WITH SERIES CONNECTION

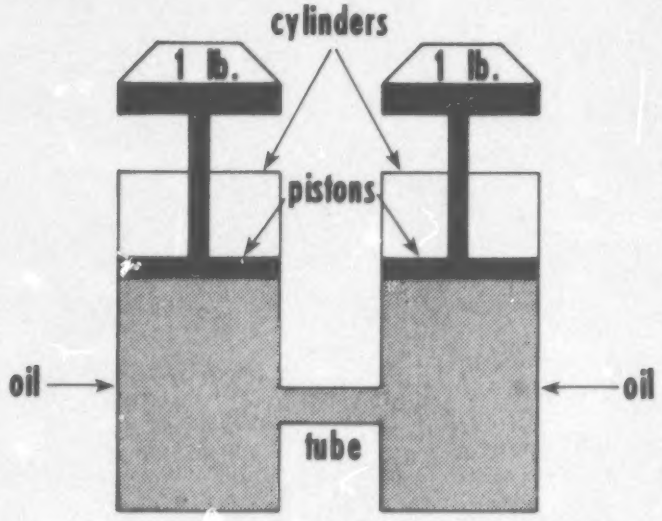


CLOSED-CENTER SYSTEM
WITH FIXED DISPLACEMENT PUMP & ACCUMULATOR

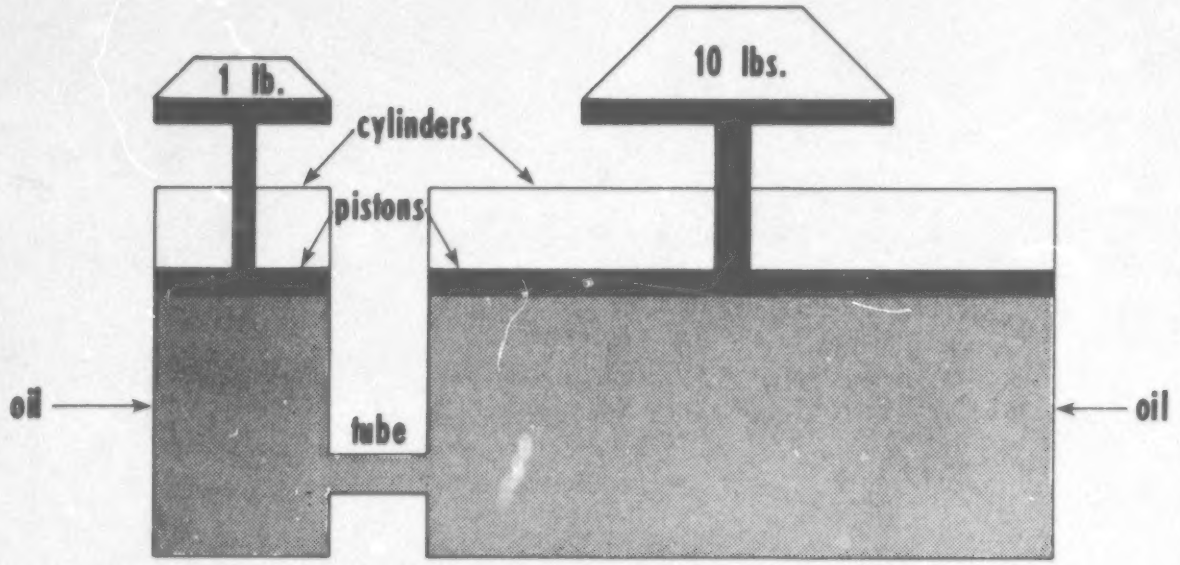
HYDRAULICS



PRESSURE IN BOTTLE THE SAME

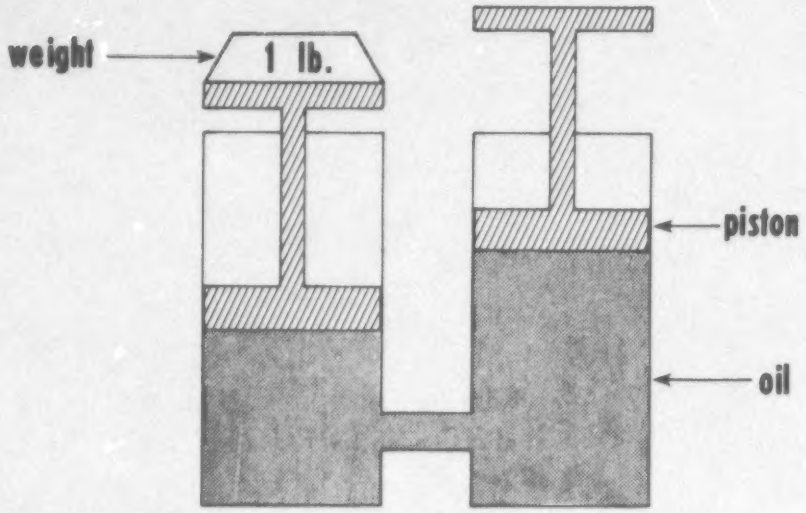


OIL AT SAME LEVEL UNDER EQUAL PRESSURE

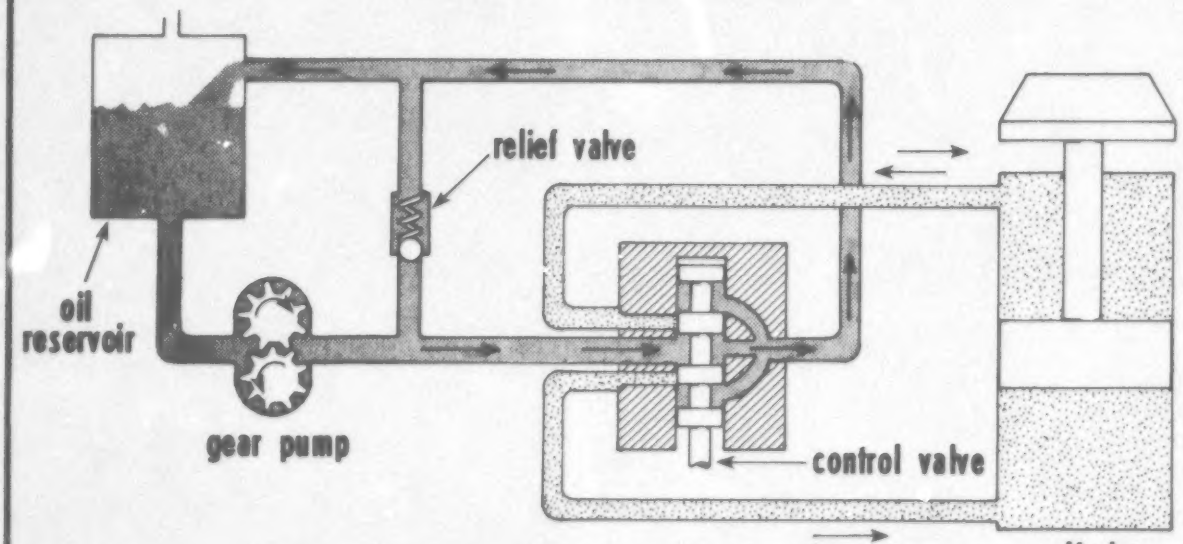


INCREASED AREA INCREASES WORK FORCE

HYDRAULICS

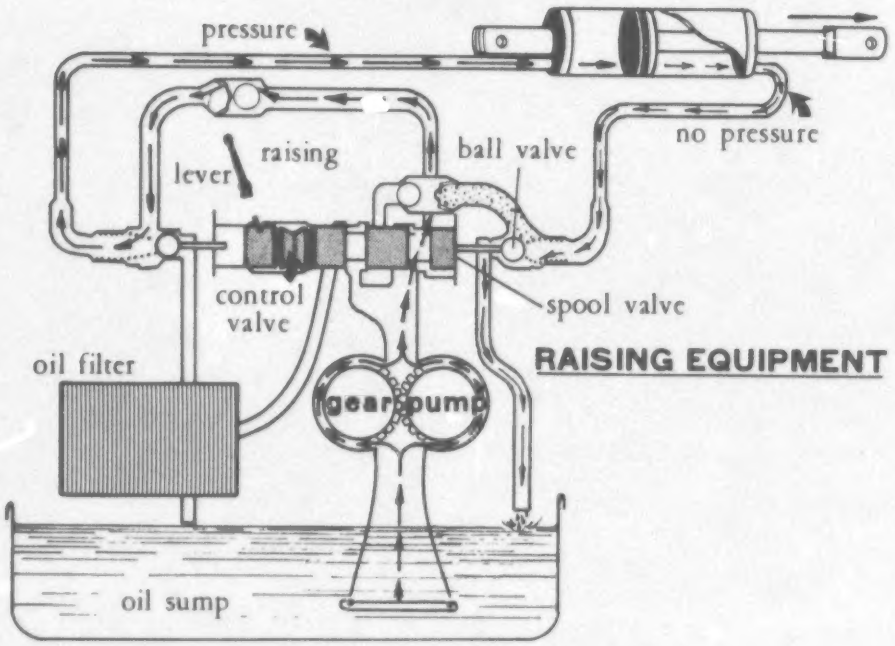


1 LB. PRESSURE FORCES ONE CYLINDER DOWN & THE OTHER CYLINDER UP

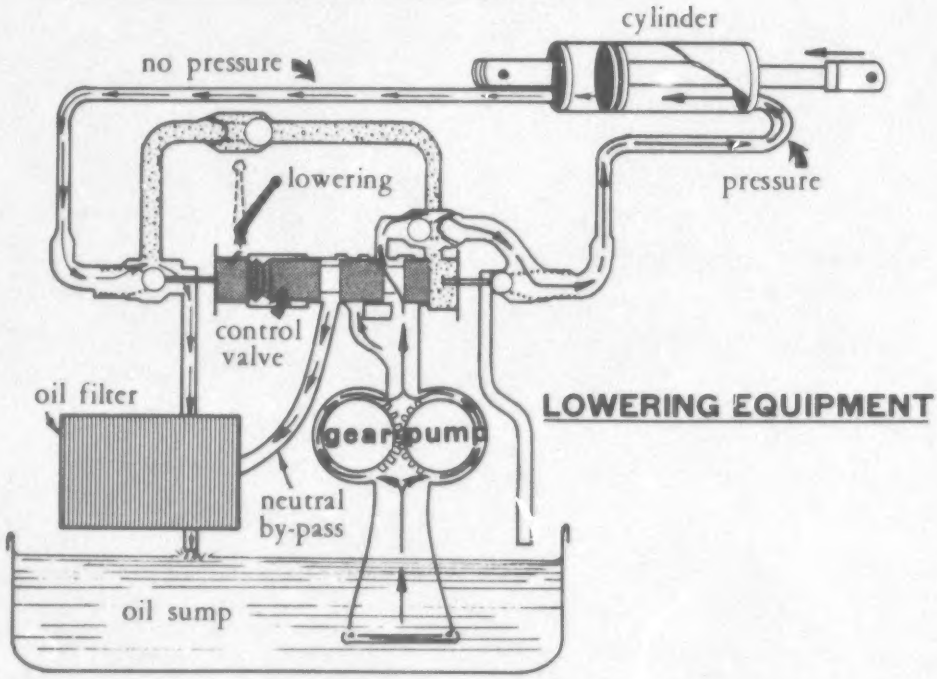


HYDRAULIC SYSTEM IN NEUTRAL

HYDRAULICS

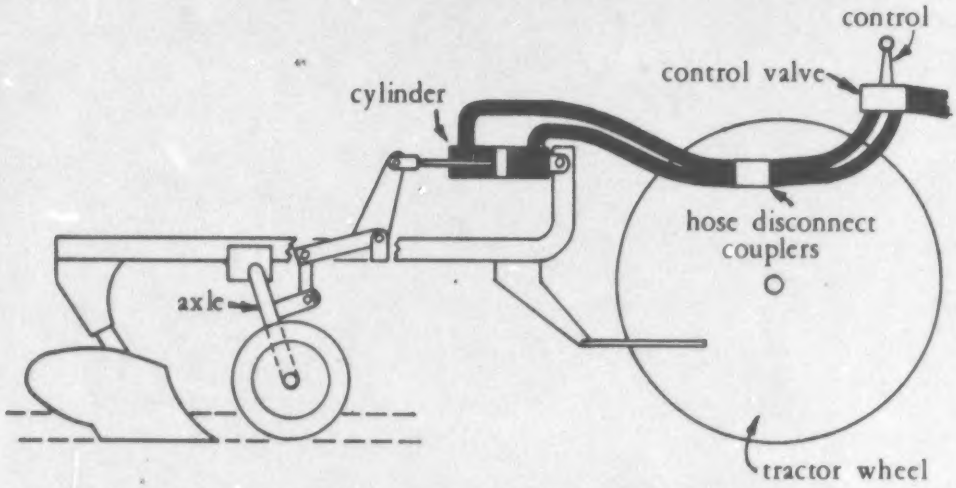


RAISING EQUIPMENT

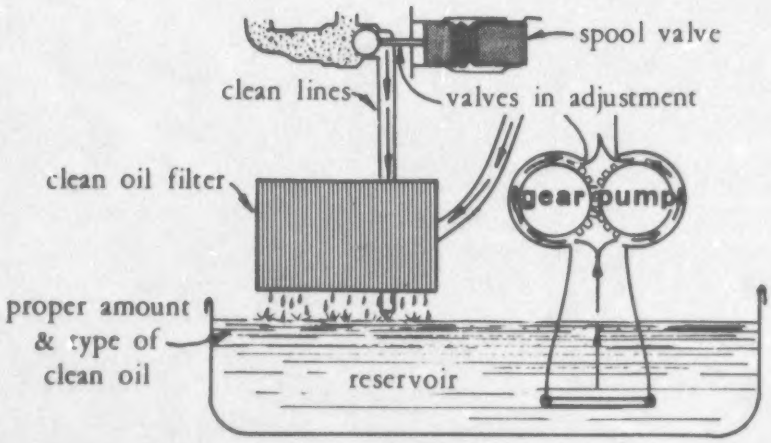


LOWERING EQUIPMENT

HYDRAULICS



METHOD OF RAISING A PLOW BY REMOTE CONTROL



ELIMINATION OF MAINTENANCE PROBLEMS

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Functional Maintenance of Farm Truck and Tractor Systems

Topic 8: Steering

Suggested Procedure and Activities: If cut-away views of the steering system are available, they will be helpful teaching aids for class discussion.

1. The Purpose of a Steering Device on a Farm Tractor

A tractor driver maintains steering control of the tractor by proper use of the steering system. The rotary motion of the steering wheel causes a side to side movement of the tractor's front wheels, The steering system gives the operator a mechanical advantage of the tractor. Usually a small amount of effort is required to steer the tractor in different directions. Wheel-type tractors are steered in about the same way as automobiles. The purpose of a steering system on a tractor is the same as an automobile. It determines the direction of movement. The one major difference in steering a tractor and an automobile is the short turn. Most farm tractors are equipped with brakes that enable the operator to turn the tractor either to the right or to the left.

2. The Types of Steering Gears

The actual designs of steering systems are different on different makes and models of tractors. However, many basic parts of the steering mechanism are the same on most tractors.

The types of steering gear and their function are:

Transparency No. 1

a. Manual Steering - The front wheels are moved from side to side by a worm-and-sector or worm-and-nut type gear which is enclosed in a sealed lubricant case. The movement of the steering wheel causes the worm gear to move a lever arm which is connected to the front wheel assembly by a cross arm and tie rod linkage.

On tricycle front wheels, the worm-and-sector gear is connected to the turning spindle, or a steering arm is used to connect the rear mechanism with the front wheel mechanism.

The basic component parts of one type of a manual steering gear are: steering shaft housing, steering wheel, steering wheel shaft, steering

worm mechanism, steering shaft, steering shaft arm, and steering drag link. One of the most common types of manual steering gear is the recirculation ball type. The cylinder has a groove resembling the threads on a bolt filled with small steel balls. When the worm shaft is turned, the ball nut moves up and down turning the sector which turns the wheel mechanism.

Transparencies Nos. 2a and 2b

b. Hydraulic Assist Steering - A hydraulic booster assists the turning of the wheels in this type of steering system. The function of the system is as follows:

When the steering wheel is turned to the right, the pump forces oil through the spool valve to the steering cylinder at the front wheels. The piston moves a rack and pinion device which helps turn the wheel. Oil in the other side of the cylinder flows back into the reservoir. If the steering wheel is turned to the left, the function is the same except that the pump sends oil to the other side of the cylinder. In case the actuator (hydraulic cylinder) is located with the steering valve, the mechanical link to the wheels is operated manually and by the hydraulic unit. The action is transferred to the front linkage.

Transparency No. 3

c. Complete Hydraulic Power Steering - There is no mechanical linkage between the steering wheel and the wheel or wheels in this system other than the sector gear. The power steering system functions in the following manner:

A right turn of the steering wheel rotates the worm gear to the right which forces the sector gear to rotate. This movement forces the valve spool to the right, opening the oil flow to the right end of the cylinder, thus turning sector gear to the right. A reverse action takes place to turn the tractor wheels to the left.

When the wheels are directed straight ahead, both sides of the power cylinder are open, and the same amount of oil pressure is held on each side of the cylinder plunger. The thrust bearing clearance is the same on each end of the valve control.

Power steering is considered optional equipment on most modern tractors. The main advantage of power steering is ease in handling the tractor when turning. A maximum force of four to five pounds applied to the steering wheel can turn the tractor if it is equipped with power steering.

3. Maintenance of the Manual Steering System

Transparencies Nos. 4a and 4b

The manual operated steering system requires several different types of maintenance practices to keep it operating properly. The maintenance procedure is as follows:

a. Check the gear box periodically (every six months or after about each 400 hours operation) or as recommended by the operator's manual. Add oil to the proper level. If the tractor case is equipped with a pressure fitting, add multipurpose grease.

b. If there is a vent plug on top of the housing, keep it open to relieve pressure caused by heat.

c. Check the gears for back-lash and make adjustment according to the operator's manual. On certain makes of tractors worm shaft end play, upper spindle end play, and sector shaft end play can be adjusted.

d. Check the steering linkage and apply lubricant through the lubrication fitting. Parts that need lubricating after several hours (about 10) of operation are tie rod ends, axle pivots, king-pins, and steering knuckles.

4. Maintenance of the Power Steering System

The hydraulic powered steering system may be operated on a special oil recommended by the manufacturer, transmission fluid, or a light grade of motor oil. The operator's manual should be consulted to assure the use of the proper fluid. In order to maintain a power steering system the following procedure should be used:

a. Check the level of the oil and add recommended oil to mark on the dipstick Clean around dipstick before removing.

b. Correct any leaks around fittings, hose clamps, and line connections.

c. Bleed air from the system by either draining and refilling it or operating the system for several cycles free of load. Air in the lines will cause improper lubrication.

d. Drain and refill the power steering system as recommended by the operator's manual. The steps for draining and refilling are:

Clean around the work area on the system.

Remove drain plug or disconnect a lower hose and drain fluid. Replace drain plug in hose.

If the system has a filter replace it.

Refill the reservoir to the full mark (mark on dipstick).

Start the engine and turn the steering wheel several complete turns.

Stop the engine and add fluid if it is needed.

e. Check the upper spindle end play and make adjustment if necessary. Make other adjustments that are recommended by the operator's manual.

f. Lubricate the lower pedestal bearing, tie rod ends, axle, steering knuckles, and king pins. It may be necessary to lubricate these parts about every ten hours of operation.

References:

Promersberger, William J. and others, Modern Farm Power, Prentice-Hall Inc., Englewood Cliffs, NJ, 1971

Stone, Archie A. and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, NY, 1967

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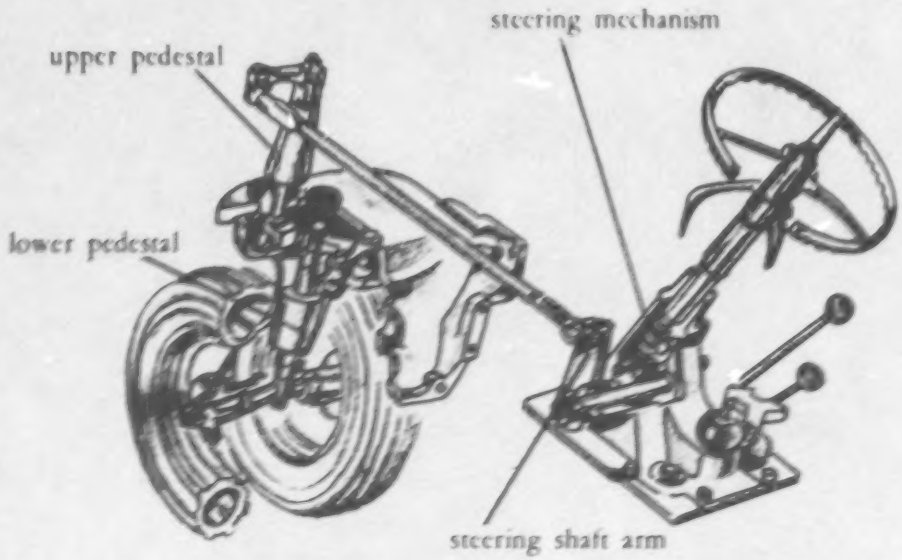
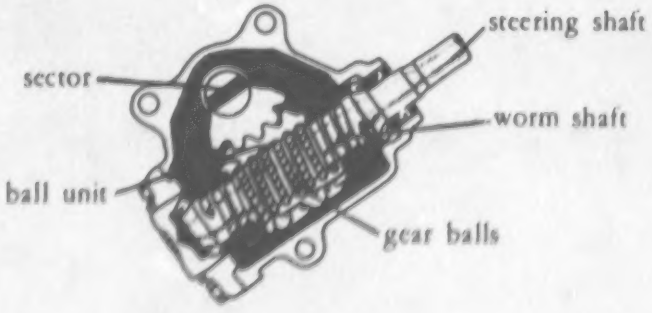
STEERING SYSTEM

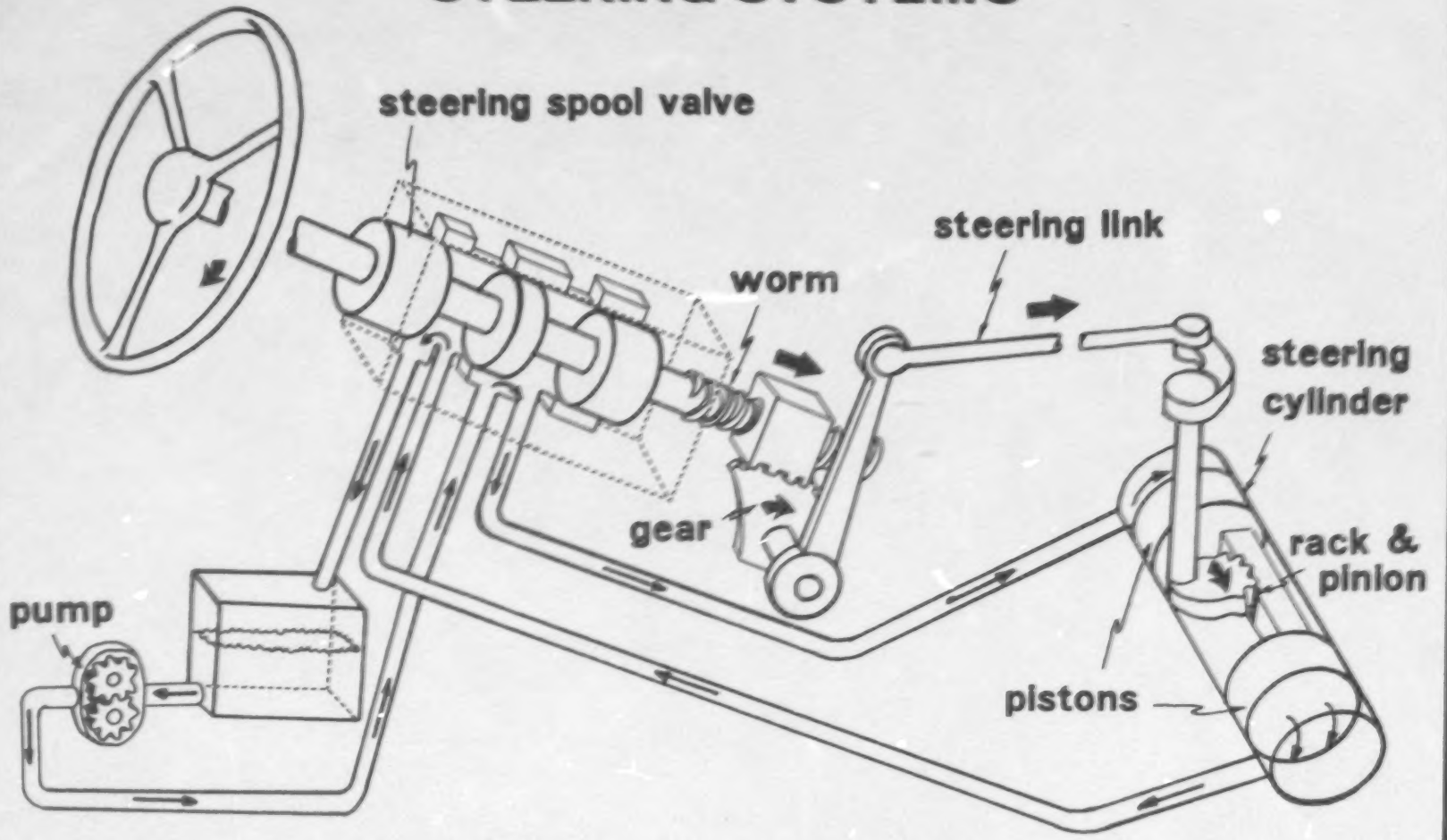


MANUAL STEERING SYSTEM ON TRICYCLE TWIN FRONT WHEELS



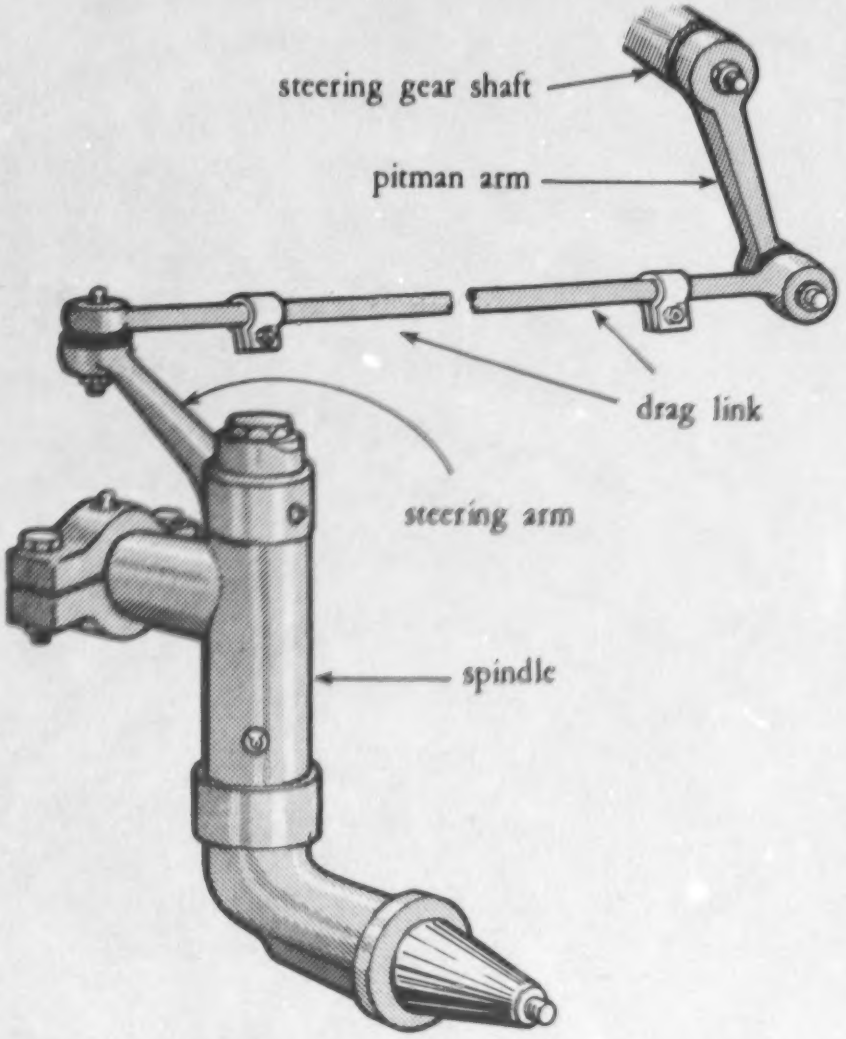
TRICYCLE STEERING MECHANISM

STEERING SYSTEMS



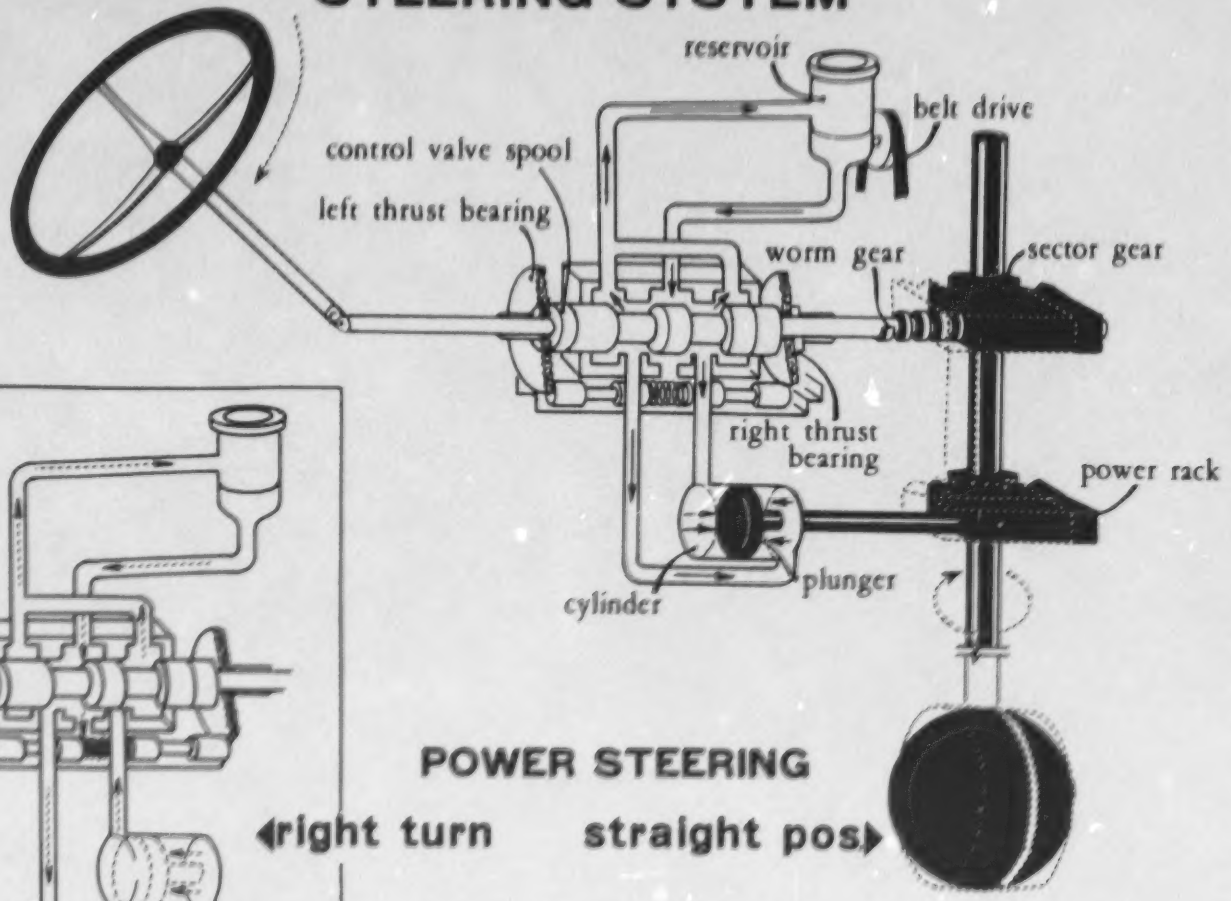
HYDRAULIC ASSISTED SYSTEM

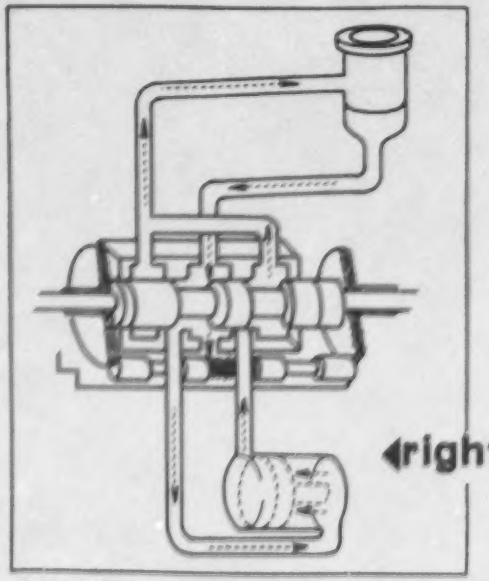
STEERING SYSTEMS



FRONT AXLE & STEERING LINKAGE

STEERING SYSTEM





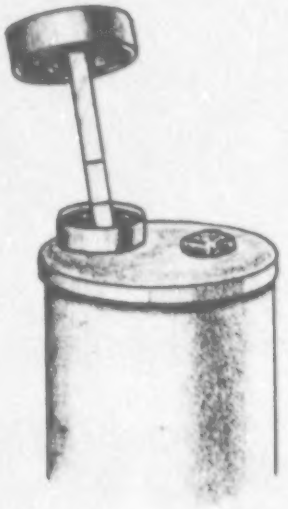
POWER STEERING

right turn straight pos

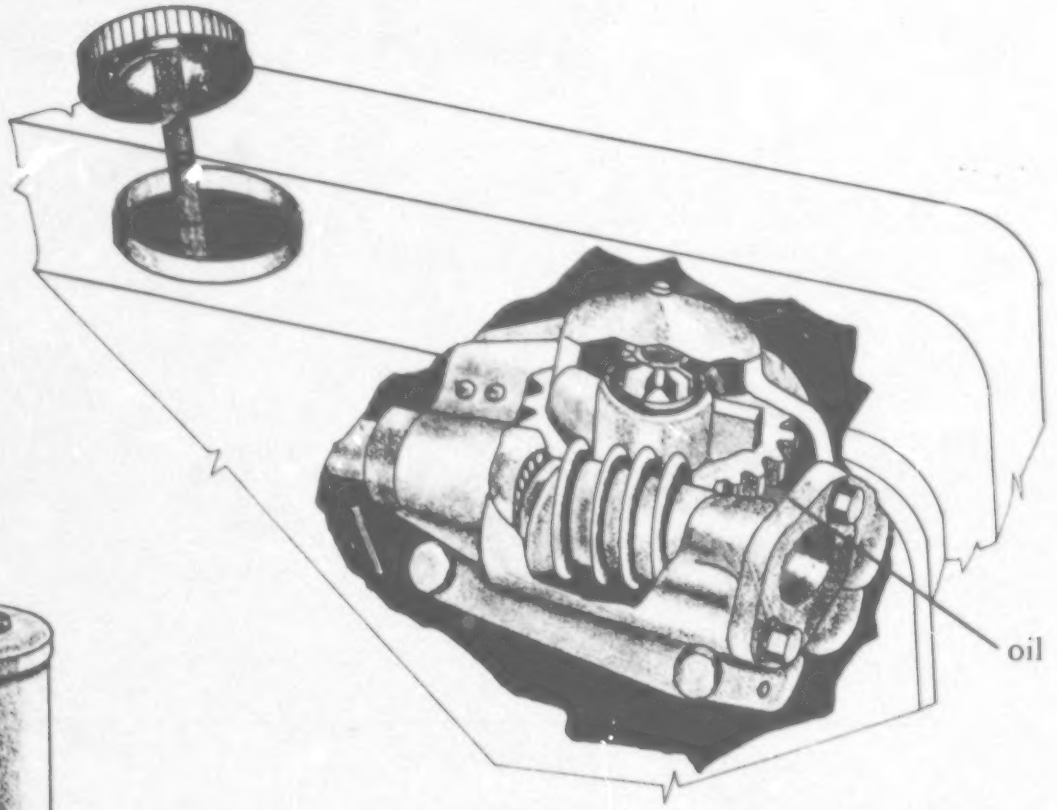
DENOTES RIGHT TURN

DENOTES STRAIGHT POSITION

STEERING SYSTEM

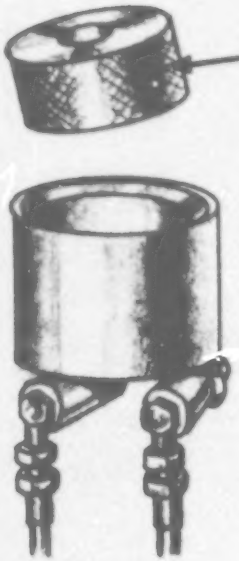


USE of DIPSTICK
to CHECK OIL LEVEL
HYDRAULIC SYSTEM

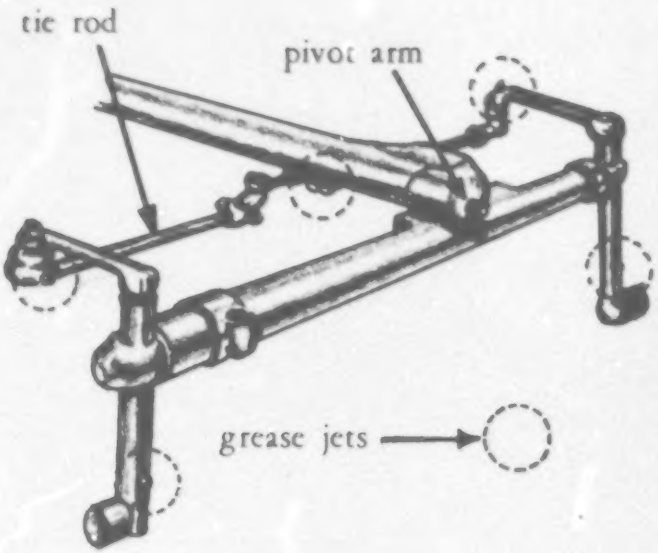


STEERING MECHANISM
on UPPER PEDESTAL
MANUAL SYSTEM

STEERING SYSTEM



HYDRAULICS - STEERING FILTER ELEMENT IN RESERVOIR



TRACTOR FRONT-END ASSEMBLY

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit C: Function and Maintenance of Farm Truck and Tractor Systems

Topic 9: Tires and Wheels

Suggested Procedures and Activities: The use of a tire cross section or cut away and two or three tires to be examined during the classroom discussion will aid the student in determining tire structure, size, type, and tread.

1. Tire Construction

A cut away drawing helps to see the tire's vital parts.

a. Bead - The beads anchor the tire and rim together and are the foundation of the tire. All of the tire plies are tied to the strong bundle of wire, which is the bead, to prevent any change in shape or in the fit on the rim.

b. Body Plies - Layers of rubber-cushioned fabric or cord make up the body. The built-in strength in this part of the body holds in inflation and cushions shock. Each cord in every ply is surrounded by a resilient rubber compound. This cord may be rayon, nylon, cotton, polyester, or other materials. Nylon and rayon are the most popular, but polyester is coming into more common usage.

c. Ply Rating - All off-the-road tires are ply rated. The ply rating was used formerly to tell how many actual plies the tire had. Now it identifies a given tire with its recommended load when used in a specific type of service. As a comparison of two-and four-ply construction, to get the same strength, the two-ply cords are larger than the four-ply cords.

d. Bias Ply - In the normal tire, ply cords run from one tire bead to the other at an angle. Alternate plies run in opposite directions; the construction gives rigidity to the thread and sidewall.

e. Belted Bias Ply - The tire body is similar to the bias tire, but the body is surrounded by a semi-rigid belt. These belts are made up of very low angle cords which surround the tire body under the thread. These belts help give a more rigid sidewall and tread life.

f. Belted Radial Ply - The body cords run across the body from bend to bend almost at right angles. Fairly rigid cord belts surround the tire body under the tread. This construction gives better tread life and better tread support.

g. Wire-Reinforced Ply - On some large tires for earthmoving or other heavy equipment, a layer of wire is built in between the body and tread of the tire. This protective layer of wire keeps most cuts from penetrating into the tire cavity, keeps many tread cuts from growing, and tends to keep cuts closed so that sand and dirt will not enter and foster separation.

h. Sidewalls - The rubber covering on both sides of the body are called sidewalls. These are designed to flex and bend without cracking when used under normal and extreme sudden shock.

i. Tread - The tread is the part that contacts the road or ground. In most cases it must provide traction, resist cuts, and provide long wear.

j. Tubeless Inner Liner - This type of liner covers the inside form from bead to bead and serves as an air retainer.

k. Flaps - This type of protective item is used on tube type tires to protect the tube when it comes in contact with the wheel rim or tire beads.

Transparency No. 1

2. Tire Codes for the Different Types of Tires

Many types of tires are in use, especially in agriculture. To simplify things, a uniform code has been adopted by both the Tire and Rim Association and the Rubber Manufacturer's Association (RMA). The standard code is marked on the side of the tire, and it normally consists of a number plus a letter. As an example, in R-1, the letter R means it is a rear tractor tire. The number that follows tells the specific type of rear tractor tire.

Few tire makers will make all of the tire types for which codes have been established. All similar tires will be marked with the identical code. If you are not certain which tire is best for your particular purpose, consult a reputable tire dealer for advice. Some tire manufacturers will add the letter "O" after the industry code to show the tire has open tread design. They may also add the letter "C" to indicate a closed tread in the R-2 classification,, and some types of tires may have an arrow showing the way the tire is to rotate.

There are many common terms used to classify farm equipment tires. Such terms as "first line", "second line", "top grade", and "100 level" are common terms used in the tire business when referring to tire quality.

The quality of the various makes of tires cannot be compared by using these terms. The "first line" tire of one company does not mean this tire is equal to the "first line" tire of another company. Also, different makes of tires that sell for about the same price may or may not be of the same quality.

3. Tire Sizes and Pressure

a. If the tire marking on the sidewall of an off-the-road tire is 13.9/36, the number 13.9 means the width from one side to the other in inches on a mounted tire. The "36" is the rim diameter in inches. Older tires that have dual numbers such as 12.4 (mounted width) and 11-28 (11 by 28 inch rim) are being replaced as the older type rims are becoming obsolete.

b. Some common tire sizes and pressures are as follows:

Size	Ply	Pressure
	Front Tires	
All 4.00 sizes	4	20 lbs. - 44 lbs.
All 5.00 sizes	4	20 lbs. - 36 lbs.
All 5.50 & 6.00 sizes	4	20 lbs. - 32 lbs.
All 6.50 sizes	4	20 lbs. - 28 lbs.
All 7.50 sizes	4	20 lbs. - 24 lbs.
All 5.50 & 6.00 sizes	6	20 lbs. - 48 lbs.
All 6.50 sizes	6	20 lbs. - 44 lbs.
All 7.50 sizes	6	20 lbs. - 36 lbs.
	Rear Tires	
9 sizes - All 9.5	4	12 lbs. - 18 lbs.
10 sizes - All 11.2	4	12 lbs. - 16 lbs.
11 sizes - All 12.4	4	12 lbs. - 14 lbs.
12 sizes - All 13.6	4	14 lbs. - 14 lbs.
13.9	4	14 lbs. - 14 lbs.
10 sizes - All 11.2	6	12 lbs. - 26 lbs.
11 sizes - All 12.4	6	12 lbs. - 22 lbs.
12 sizes - All 13.6	6	14 lbs. - 20 lbs.
13.9	6	14 lbs. - 20 lbs.
13 sizes - All 14.9	6	14 lbs. - 18 lbs.
15.5	6	14 lbs. - 18 lbs.
14 sizes - All 16.9	6	16 lbs. - 16 lbs.
15 sizes - All 18.4	6	16 lbs. - 16 lbs.

Drive Wheels - Liquid Ballast

Size	Ply	Gallons Liquid
13.6-28	4	74
14.9-28	6	92
15.5-38	6	112
16.9-34	6	140
18.4-34	6	170

Transparency No. 2

4. Proper Tire Inflation and Tire Ballast

a. The proper inflation of tires is vitally important to their service life. Tires are made to work with a certain amount of sidewall bulge or deflection. The correct air pressure will insure proper traction, support of load, and flotation and will prevent excessive flexing, which may cause overheating of the tire. The effects of improper inflation are as follows:

(1) Underinflation

Severe stress on sidewalls causing cracking
Excessive wearing of tread on each side of the tire due to cupping
Excessive wear on shoulders caused by rim bruises
Twisted or broken valve stems
Powered equipment difficult to steer
Tire loose on rim causing it to slip

(2) Overinflation

Excessive wear especially on edge of tread bars
Excessive wear in center of tire
Possible fabric damage if tire hits sharp object
Tire slips on certain surfaces easily
Tread fails to clean when traveling in certain type of soil
Equipment ride is rough

b. Proper tire inflation is necessary at all times and especially when a machine is being continuously used; therefore, it is important to have an accurate pressure gauge. There are high and low pressure type gauges. A high pressure gauge is usually not satisfactory for checking low pressure, since they are marked in 5-pound increments. Low pressure gauges are

graduated in one-pound increments. Things to remember about tire pressure are:

(1) Always check tire pressure and inflate if necessary when the tires are cold. As the tires get hot from use, the air will expand and the pressure will increase.

(2) Never "bleed" pressure from a hot tire. The expanded air, when let out, will result in an underinflated cool tire. If the tire is quite overinflated due to heat, you should reduce the load or the speed or both.

(3) If a tire becomes low of pressure while in operation, adjust the pressure to that of other tires of the same size on the vehicle.

(4) Always use a liquid-type gauge when checking pressure in tires filled with liquid ballast. If possible, always check pressure with the valve stem at the bottom, wash gauge clean, and dry after use. If it is undesirable or impractical to have the valve stem at the bottom, have the stem at the top, and add about 1/2 pound of pressure to the gauge reading for every one foot height of liquid in the tire.

(5) Tractor and implement tires are used most of the time in off-road or field conditions where the low pressure tire will give proper tire to ground contact. When operating over hard surface roads low pressure will cause tire distortion and tread bars to squirm and wear excessively. If the tires are to be used excessively on hard surface roads, increase the pressure to manufacturer's recommendations to help prevent wear. When the machine is placed back under field conditions release some air pressure so the tire to ground contact will again be proper.

c. Tire ballast (substance added to give stability) is very important to the proper use of tires. Many machines are not heavy enough to give proper traction, and with added weight more tractive power can be exerted. However, too much added weight causes compaction of the soil and increases the resistance of the machine. Proper weight will cause some slippage (10 to 15 percent), whereas too much weight eliminates slippage and results in sharp, distinct tire tracks in the soil. Actually the amount of ballast depends upon the following conditions:

(1) Soil Surface - Less weight is required on a firm surface than on a loose surface. Firm surface may be such as corn stubble or hay pasture, while loose surface is as a plowed field.

(2) Type of Implement - Some implements transfer more weight to the rear wheels than others. Towed implements need more traction tire ballast than integral or rear mounted (semi-integral) implements.

(3) Travel Speed - More weight is needed for slower speeds than for higher travel speeds.

(4) Tractor Horsepower Output - Less weight is required for 80 - horsepower than for 100 - horsepower engines. Less weight is also required for a machine not working under full load. Operating at 3/4 load requires 3/4 as much rear weight as the same machine operating at full load.

(5) Type of Tires - Usually oversized tires give better traction. A conservatively used tire (all types) will usually give better service than one used to capacity.

d. Some types of tire ballast:

(1) Cast Iron Weights - Cast iron weights are obtained from tractor manufacturers. Most wheels weights are 40 to 140 pounds. Some factories may install heavier weights as original equipment. General practice is to install liquid ballast and then add cast iron to specifications.

(2) Liquid Ballast - Liquid ballast is almost always water with calcium chloride added to prevent freezing. When installing liquid you will normally fill the tire to 75 percent or to valve level. This is recommended because:

(a) The air chamber is needed to retain the pneumatic principle.
(b) The water or liquid solution will not compress. If the tire is filled to 100 percent, it is unable to absorb any shock and has no bruise resistance.

With 75 percent ballast, there is not too much extra weight for light load operation.

(3) Dry Ballast - Dry ballast is used sometimes for weighting tires. Some dealers have the equipment to install the dry ballast. Some manufacturers are installing dry ballast at the factory; 87 or 95 percent is a normal fill of dry ballast.

Advantages of dry ballast:

(a) It will give 20 to 30 percent more traction with less tire wear.

(b) Dry ballast will reduce the inherent bounce of rubber tires and make for a smoother ride.
(c) There is no danger of freezing. The dry material is treated to resist moisture.

Dry ballast is furnished from the manufacturer in three weights: 10, 15, and 20 pounds per gallon. The 15-pound is recommended for 90 to 95 percent of all farm tractors, while 20-pound is recommended for heavy equipment.

Some disadvantages of dry ballast:

(a) It requires higher initial cost than other types.
(b) It requires outside servicing with special equipment.
(c) Loss of ballast will occur if there is tire, tube, or valve failure. Dry ballast is showing its potential, and some manufacturers are now recommending its use with their equipment.

Transparency No. 3

5. Wheel Rims

a. Tractor and Implement Rims - Tractor and implement rims are made in many shapes. Most implement and tractor rims use a tube with the tire, but some rims and tires are made to be operated without tubes.

There are three measurements used to determine rim size. They are: rim diameter, rim width, and rim flange height. The diameter and width of a rim is measured in inches. The height is identified by letter (H.I.). The flange will indicate a certain flange height. For example, an AK rim is 0.77 inches high.

Four types of tractor and implement rims are:

Wide base drop center rims
Double bevel drop center rims
Deep will drop center rims
Drop center rims for front wheels of tractor and implements

b. Service of Wheel Rims - If rims are properly cared for when the tractor

is operating and not in use, there will be fewer service problems than on many other moving parts of the tractor. Rim service performed is as follows:

(1) If a flat tire should occur, the machine should be jacked up at once to protect the tire and wheel rim. Running a machine with a flat tire will not only damage the tire and tube, but can do a great deal of damage to the rim. If, after repairing the tire and tube, you replace it on a poor or damaged rim, you are likely to encounter much more trouble.

(2) Check the rim for any dents or sharp places which could damage a tire. Rim flange and bead seats should be clean. Use a wire brush, coarse steel wool, or emery cloth to clean the rim.

(3) When installing the wheel rim on the implement, the wheel lugs should be tightened in the proper sequence. This will insure that the wheel is against the hub properly and that binding or bending will not take place.

6. Adjusting Toe-In on Wide Axle Tractors and Machines

a. Toe-in means that the front of front tires are slightly closer together than the back. The proper toe-in causes the machine to track in a straight line and actually reduces wear on the tires. It also causes the steering of a machine to be easier. If the wheels are set parallel they will toe-out. Toe-in should be checked periodically or before the machine is put into use at the beginning of the season. Other things to check regarding toe-in are when the machine becomes difficult to steer, when the wheel spacing is changed, when front parts are exchanged or repaired, and when hitting a hole or solid object with a front wheel.

b. Some steps that may followed when determining the need and adjusting toe-in:

(1) Operate the machine on level ground before measuring wheel tread at both front and rear of wheel. Measurements should be made at hub level.

(2) Use the operator's manual for proper specifications. Most machines may show a toe-in from 1/8 to 3/8 inches less for the front than for the rear.

(3) Some machines may have a single tie rod. This type of machine may be adjusted by loosening the tie rod clamp or clamps and screwing in or out the tie rod end until the adjustment is properly made. Then the clamps are retightened.

(4) If the machine has a tie rod for each wheel, both tie rod ends must be adjusted. Turn each end after loosening the clamps so that both front wheels will have the same toe-in.

References:

1. Stockel, Martin W., Auto Service and Repair, The Goodheart - Willcox Company, Inc., South Holland, Illinois, 1978

2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

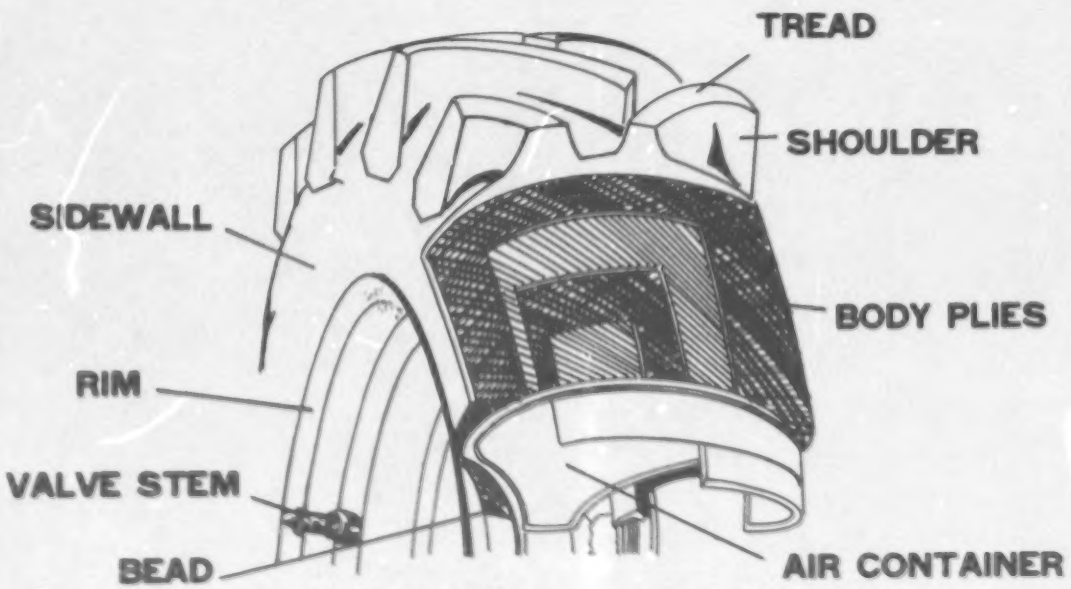
3. Fundamentals of Service - Tires and Tracks", Deere and Company, Moline, Illinois, 1970

4. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

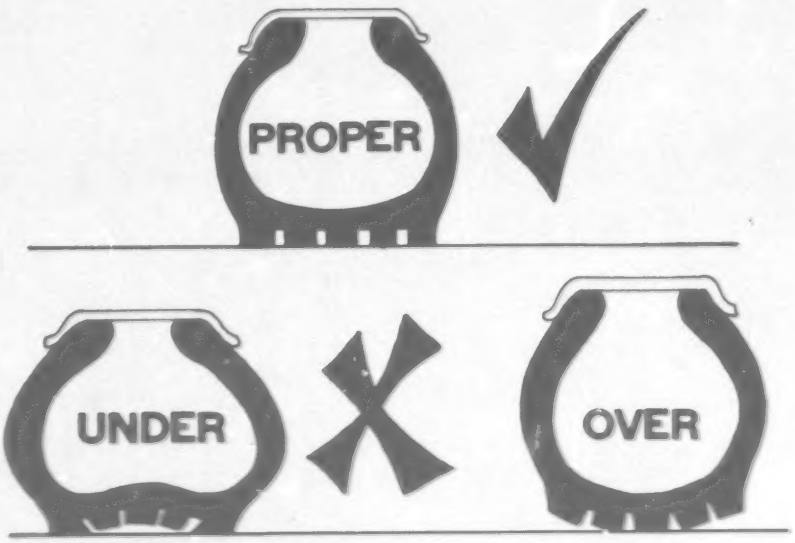
STANDARD INDUSTRY CODES FOR TIRE TYPES

TYPE OF TIRE	CODE
FRONT TRACTOR	
RICE TREAD	F-1
SINGLE RIB TREAD	F-2
DUAL RIB TREAD	F-2D
TRIPLE RIB TREAD	F-2T
INDUSTRIAL TREAD	F-3
DRIVE WHEEL TRACTOR (REAR)	
REAR WHEEL, REGULAR TREAD	R-1
CANE AND RICE, DEEP TREAD	R-2
SHALLOW, NON-DIRECTIONAL TREAD	R-3
INDUSTRIAL, INTERMEDIATE TREAD	R-4
IMPLEMENT	
RIB TREAD	I-1
TRACTION TREAD	I-3
PLOW TAIL WHEEL	I-4
SMOOTH TREAD	I-6
OFF-THE-ROAD TIRES (INDUSTRIAL)	
RIB	E-1
TRACTION	E-2
ROCK	E-3
ROCK, DEEP TREAD	E-4
ROCK, INTERMEDIATE	E-5
ROCK, MAXIMUM	E-6
FLOTATION	E-7

-·—·- ALSO INCLUDES SIMILAR TREAD FOR "G", "L", AND "ML" SERIES CODES.



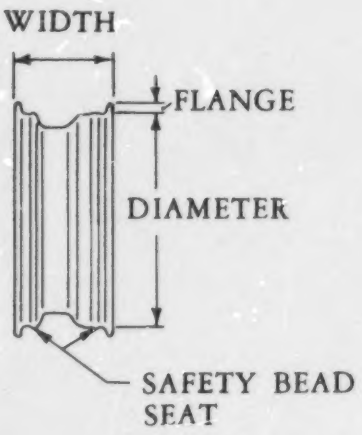
PARTS OF A TIRE



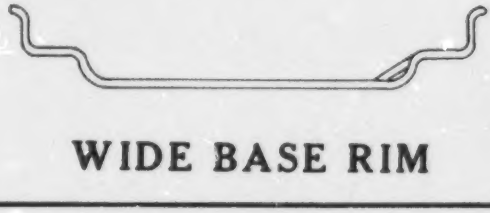
TIRE INFLATION

WHEEL RIMS

DOUBLE BEVEL RIM

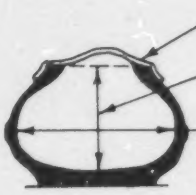


RIM MEASUREMENTS



WIDE BASE RIM

DEEP WELL



TIRE MEASUREMENTS

DROP CENTER (TRACTOR FRONT & IMPLEMENTS)

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit D: Farm Machinery and Equipment

Topic 1: Types and Adjustments

Suggested Procedures and Activities: One of the more common types of field machines may be used as a teaching aid during the class discussion. It may be necessary to conduct the class in the farm mechanics shop if a machine is used. A disk harrow, grain drill, planter, moldboard plow unit, cultivator, mower, baler, or combine could be used for demonstrations in the laboratory.

1. General Adjustments on Farm Machinery

Adjustments made on machinery usually follow the inspection and repair jobs. There are two major adjustment periods- prefield and field adjustments. Field adjustments are made immediately after the machine is put into operation. If field adjustments are properly made, it will not be necessary to continue making adjustments during the time the machine is in use, unless some part of the machine breaks or is damaged.

Most machinery adjustments are made in the field. Preliminary adjustment should be made prior to entering the field. The operator's manual should be referred to when making prefield and field adjustments unless the operator is familiar with the machine, parts, and their functions. The functions and parts of machinery can be discussed and demonstrated as each type of machinery is studied.

2. Disk Plows

Disk plows are used where it is difficult to use a moldboard plow. They have an advantage over a moldboard plow in dry and hard soils. They are also used in gumbo, waxy muck, sticky soils, and on hardpans where the moldboard will not scour well. The disk plow is also preferred for rocky, rooty, and stumpy soils.

a. The three most common types of disk plows are:

(1) Direct-Mounted Plows - These plows are attached to the tractor by one-, two-, or three-point hitch linkages and can be raised or lowered hydraulically. They usually are rear-mounted and have a rear wheel to absorb the side thrust.

(2) Semi-Mounted Disk Plows - These disk plows are attached to the tractor drawbar or by a special drawbar. They are raised by moving a lever at the front of the plow. A long rod which extends to the tractor drawbar is used to steer the rear wheel.

(3) Trailing Disk Plows - These plows have three wheels for support and can be pulled by any make of tractor.

b. Draft created by the disk plow is about the same as the moldboard plow; but since the disk plow is usually much heavier than the moldboard plow, its draft is usually greater. The moldboard plow may be set to operate mainly on suction, whereas the disk plow will penetrate the soil due mainly to its weight.

Transparency No. 1

c. The major parts of the disk plow include:

Disk blade	Wheels
Disk scrapers	Wheel weights
Beams and frames	Depth screw
Bearings	

3. Disk Harrows

Disk harrows are referred to as disk plows and disk tillers. A disk turns the soil in one direction, whereas a disk harrow turns the soil in two directions. The concave edge of a disk harrow disk cuts the soil, and the back edge raises the soil and pushes it to the side as a moldboard. The disks on a disk tiller operate at about a 45-degree angle as they cut and mix the soil and trash.

a. The two kinds of disk harrows are as follows:

(1) Single action harrows may consist of two gangs (a number of disks on one shaft rotating in the same direction).

(2) A double-action disk harrow is made up of two sections, one section trailing behind the other. The double-action harrow is called a tandem disk. Furrows created by the front section are turned back by the back section.

b. Parts of the disk harrow are:

Disk blades	Angling devices
Hitches	Wheels (some harrows)

Leveling devices Frame
Scrapers

4. Moldboard Plows

In many agricultural areas the moldboard plow is the most commonly used piece of equipment for seedbed preparation. The plow slices, lifts, and turns the soil. The plow may be one of four types: stubble, general purpose, breaker, or highspeed. Each of these types perform a specific function.

a. The three types of moldboard plow draft are:

(1) Trailing
Regular -- one to eight bottoms
Two-way -- one to four bottoms
Middlebreakers -- one to four bottoms

(2) Mounted
Regular -- one to five bottoms
Two-way -- one to two bottoms
Middlebreaker -- one to four bottoms

(3) Semi-mounted
Steerable -- over five bottoms
Non-steerable -- one to five bottoms

b. Plow parts include:

(1) The beam or frame holds the bottoms in the correct position.

(2) The frog is that part of the plow bottom to which all other bottom parts are attached.

(3) The share is that part of the plow bottom that cuts the underside of the furrow slice away from the land.

(4) The moldboard is the part that turns the furrow slice.

(5) The landside is the long flat metal piece which absorbs the side force created when the furrow is turned and levels the plow bottom into a free floating position.

(6) The plow bottom lifts, turns, and pulverizes the soil.

(7) Plow coulters are round flat disk blades used for cutting soil and trash ahead of the plow.

Transparency No. 2a

5. Chisel Plows and Subsoilers

Chisel plows and sub-soilers are different from other plows, tillers, and harrows. Chisels are used to break the hardpan, and sub-soilers are to break up the subsoil. There are several types of chisels that are used as cultivators. The depth of operation on one type is controlled by raising or lowering the frame on a set of wheels. The wheelless type is controlled by a hydraulic lift. Also, some chisels are equipped with reversible shovels, and others are equipped with sweeps to break the soil. Chisel parts are shovels or sweeps, standards, springs, frame, wheels (wheel type) and hitch. There may be several standards mounted on one frame.

A subsoiler usually consists of one to three shanks. It also may be wheeled or hydraulically mounted. The parts are: the point, standard, hitch, mask, frame, and wheels (wheel type). Usually sub-soilers require more draft than any other type of plow per plow point.

Transparency No. 2b

6. Planters and Drills

Row-crop planters and grain drills operate on similar principles. Both planters and drills open furrows for seed, drop seed from a hopper, and cover the seed. There is a difference in the two pieces of equipment; planters will drop seed in check rows or hills, and they are generally used to plant larger seed than drills. Rows are much closer together on a drill than on a row crop planter. Some so-called drills broadcast the seed.

Planters and drills may use disk, shoe, or hoe openers. Planters are usually equipped with rotating plates with notches or holes to receive the seed, whereas drills are either equipped with fluted wheel feed or double-run feed to receive the seed.

a. Kinds of planters include:

(1) Front, center, and rear mounted planters - These types of planters may have adjustable weight carrying wheels or they may be carried on beams that are raised and lowered hydraulically.

(2) Trailing Planters - These planters are drawn by a tractor. They are mounted on wheels.

Planters are also classified according to the way they place the seed. For example, a drill planter drops seed in a row at a distance apart according to the adjustment made in the seeding rate mechanism. A

hill-dropping planter collects a certain number of seed and drops them at regular intervals in hills. A check-row planter is set to drop seed in squares.

b. The major parts of a planter include:

Hopper	Driving device
Seed mechanism	Furrow opener
Seed tube	Covering device
Wheels	Frame

Most planters are equipped with a clutch to drive the plates. If the planter does not have a clutch, the drill shaft turns continuously.

c. Grain drills may be classified according to the feed mechanism and depth of seeding. Two types of feeding mechanisms are fluted force feed and internal double run. Most drills are dual purpose; that is, they can be used to sow seed shallow or deep. Surface drills sow seed shallow, and deep-furrow drills sow seed deep.

The parts of a drill are:

Hopper	Frame
Seeding mechanism	Dragbars
Seed tubes	Wheels
Furrow openers	Covering devices
	Driving devices

Transparency No. 3

7. Cultivating Equipment

Most cultivating equipment performs one or more of the following functions: kills weeds, tills the ground, aerates the soil, and stirs and mulches the soil. Light chisels, rotary hoes, spike tooth harrows, and certain types of light weight disk equipment are used to till the soil at a shallow depth and kill weeds. These field cultivators (cultivators that till and mulch the soil) are usually trailing type equipment which are mounted on wheels. Most of the row crop type of cultivators are either front, rear, front and rear, or central mounted on the tractor.

a. Cultivators are equipped with the following working points: shovels, sweeps, disks, spikes, furrows, and knives. The type of soil, crop, and weed determine the type of point that will be used.

b. The parts of a sweep assembly unit include:

Shank	Frame
Tension adjusting screw	Sweep direction clamp adjustment
Sweep setting screw	Gauge wheels (some units)

Transparency No. 4

8. Sprayers

a. Sprayers are used to apply herbicides, insecticides, fungicides, defoliants, and in some instances fertilizer. They are usually classified as high and low pressure units. For example, the sprayer may operate at over 100 pounds per square inch or as low as 20 pounds per square inch.

The low pressure sprayer is most commonly used for weed and brush control, insect control, and disease control. The parts of a power sprayer are: the tank, agitator, strainers, pump, hoses, boom, nozzles, gauges, regulator valve, air chamber, and cut-off valve. The most important part on any spray unit is the pump. The four types used on sprayers are: rotary, pneumatic, reciprocating, and diaphragm.

b. Power dusters are usually classified according to the type of power used to operate the duster-tractor power takeoff or engine. They also may be divided into outlet types-single outlet units with one hose and one nozzle and multiple outlet units with more than one nozzle.

Power dusters may have these general parts: hopper with agitator and feed regulator, fan distribution system (hose and nozzles), and power source.

If a power sprayer is engine powered it may be mounted on a trailer or hauled by a truck. A unit that is powered by a tractor power takeoff is usually mounted on the tractor.

Transparency No. 5

9. Fertilizer Distributors, Applicators, and Manure Spreaders

a. The two most commonly used dry types of fertilizer distributors are endwheel and trailing endgate which are mounted or pulled by a tractor. Fertilizer distributors are found on many farms. They may be part of a planter hopper unit, grain drill hopper unit, mounted on a cultivator, mounted on the tractor frame, pulled by the tractor, and even mounted on an airplane. Most units are mounted on wheels and pulled by tractors.

The parts of a dry type fertilizer distributor include:

Agitators and rotors	Frame
Feed shutters	Tube
Levers	Wheels and axles
Hoppers	Opener
Blades and brushes	

The end wheel type that is pulled behind a tractor may vary from about eight feet to twelve feet wide. This is the width that fertilizer is applied in one swath. Another type that broadcasts the fertilizer material is a trailing endgate distributor. Revolving disks scatter the fertilizer or lime as it is fed from a large hopper.

b. Liquid and gas fertilizer applicators are either mounted on the tractor or mounted on wheels and pulled behind the tractor. Anhydrous ammonia is handled by putting it under pressure in a steel distributor tank. At normal temperature it becomes a colorless alkaline gas. The parts of an applicator are:

Ammonia tank	Manifold
Outlet valve	Knife tube
Main and knife hoses	Applicator knife
Shut-off valve	Regulator

Nonpressure liquid tanks are pulled as separate pieces of equipment and mounted on planters and cultivators. They are used to apply complete neutral solutions (combination of nitrogen, phosphorus, and potash), nitrogen solutions, and potash solutions. Aluminum or stainless steel tanks should be used on nitrogen applicators, and stainless steel or plastic tanks are used on potash applicators.

c. Manure spreaders are usually mounted on one or two sets of wheels and pulled by a tractor. On some spreaders the spreader parts (conveyor and beaters) are operated by the tractor engine through the PTO shaft. If the spreader is not connected to the PTO shaft, the parts are powered by spreader wheels. The boxes of modern spreaders are made of steel. Major spreader parts are:

Upper and lower beaters	Conveyor or apron
Frame	Conveyor drive
Box	Spreading device

Transparency No. 6

10. Mowers and Rotary Cutters

a. Most of the cutter bar type of mowers are mounted on the tractor. These types of mowers are either mounted at the rear of the tractor or just ahead of the rear wheels. Integral rear mounted mowers receive power by V-belt

from the power takeoff. The cutter bar is lowered and raised hydraulically. If the cutter bar is mounted on the side (between rear and front wheels) it is either powered by the PTO, V-belt, or hydraulic power from the tractor. Trailing draw bar type of mowers are mounted on a single set of wheels and pulled behind the tractor. Power for the knife drive is transmitted by a V-belt, chain, or gear from the PTO.

The parts of the cutter bar type of mower include:

(1)

Cutter bar	Guard
Knife head	Knife clip
Inner shoe	Pitman
Bar	Outer shoe
Wear plate	

(2)

Mower assembly	Frame
Inner shoe	Drive assembly
Outer shoe	Swath board
Cutter bar	Pitman

b. Rotary cutters are used to control weeds and brush in pastures and fields. They are also used to shred stalks of cultivated plants. This type of mower is not used in the same manner as the cutter-bar mower. Instead of mowing the plants so that they lie in a uniform swath, the rotary mower shreds and lacerates the plants.

Rotary cutters are mounted semi-mounted on the tractor. There is also a trailing-type cutter that is mounted on wheels and pulled behind the tractor. The cutter blades are powered by the power takeoff that connects the mower direct drive. The cutting height is either adjusted by hand or by a remote hydraulic cylinder mounted on the mower.

The major parts of a rotary cutter are:

Frame	Blades
Wheels (trailing)	Drive shaft
Gears and housing	Cylinder (hydraulic lift)

Transparency No. 7

11. Hay Harvesting Equipment

a. Hay conditioners are used in hay harvest to crack, crimp, and crush the plant parts, mainly the stems, in order that more surface will be exposed to air and sunlight which hastens moisture evaporation and speeds field curing. The most common types of conditioners are:

(1) The corrugated-roll which crimps, cracks, and bends the hay either between two steel rollers or one steel and one smooth rubber roller. The rollers have ridges that resemble teeth in gears.

(2) The smooth-roll type conditioner has either two rubber rollers or one rubber and one steel roller. They are made with small grooves that aid in picking up the hay. This type of conditioner crushes the plant.

(3) Flail mowers are hay harvesting machines that are used as a conditioner. The hay is chopped by knives or hammers that are attached to a cylinder.

A hay conditioner may have the following major parts: frame, PTO drive, shield, cross drive wheels, rollers, drive mechanism, rollers, height adjustments, and equipment wheels.

b. The most commonly used hay rakes are the side-delivery, dump, and sweep. The side-delivery rake is the most popular among hay producers. This type of rake lifts the hay and places it in a windrow. The leaves are supposed to be placed inside the fluffy windrow and the stems on the outside. The parallel-bar and cylindrical-reel and finger-wheel side-delivery rakes form about the same type of windrow. These rakes are mounted on one or two sets of wheels. The left mechanism is either operated by hand or by a hydraulic cylinder that is operated from the tractor. Rake reels are powered by PTO and the drive wheels. The PTO drive receives its power directly from the engine, and the drive wheel system receives its power from wheel traction. Rake parts include:

Main frame	Drive mechanism
Reel	Reel frame
Wheels	Strippers and supports
Adjusting levers	

c. Most all hay is baled with a pick up or automatic type baler. This baler picks up, feeds, compresses, and ties the hay during a single field operation. Most balers are powered by the tractor PTO. Some heavyduty balers are powered by an engine mounted on the baler. Also, there is another type of baler that is self-propelled. A common type of baler consists of the following major parts:

Hitch	Plunger
Power shaft	Main drive gear
Flywheel	Feeder
Pickup	Auger

12. Combines

a. The combine is a harvester-thresher. It combines several harvesting

operations into one. For example, it cuts the plant, separates the seed from the head or pod, cleans straw and chaff from the seed, and conveys the seed into a container or tank.

b. Combines are classified by the width of cut and the way power is supplied. The larger combines are self-propelled, and the smaller types are powered by the power takeoff from the tractor. The least popular is powered by an auxiliary engine. Some self-propelled combines can cut swaths 20 feet wide. The small PTO driven type may cut a swath no more than five feet wide.

Transparency No. 8

c. A combine can harvest most any type of small grain seed-that is, with proper adjustments. It may be necessary to make adjustments in the principal units listed below:

Cutting	Separating
Feeding	Cleaning
Threshing	Grain-handling

d. The major parts of a combine and their functions are:

(1) The reel moves the plant against the cutter bar and sweeps the cut plant onto an auger or platform. It is located above the platform and cutter bar.

(2) The cutter bar functions in the same manner as a cutter bar on a mower; it cuts the stalks or stems.

(3) The feeding unit on most combines consists of a platform auger, feeder canvas, and feeder. The auger delivers the plant to the feeder, and the feeder delivers it to the cylinder.

(4) The cylinder and concaves are considered as the major threshing unit. Grain is separated from head by angle bars located on the cylinder and in the concave. Some combines are equipped with iron-tooth-type cylinders and concaves. Some loose grain is removed from the straw by a beater that pulls the straw from the cylinder and sends it to the straw rack.

(5) The straw rack is considered the separation unit, even though most of the grain is removed and passed through the cylinder grates. Final separation of grain from straw takes place on the straw rack as the straw is tumbled and tossed. Straw is regulated

over the rack by the beater check flap. The grain pan catches the grain from the concave, cylinder beater grate, and straw rack. The straw travels the full length of the straw rack and is discharged from the combine.

(6) The cleaning unit cleans chaff and other material from the grain. The chaffer is an extension of the grain pan. The cleaning fan blows air through the chaffer, chaffer extension, and shoe sieve. Chaff and light straw is blown out of the combine. Grain is allowed to fall through the chaffer and shoe sieve where it is picked up by the auger.

(7) The grain auger moves the grain to the grain elevator. The grain elevator conveyor chain delivers the clean grain to the grain tank. Unthreshed heads move across the chaffer and shoe sieve to the auger from which they are routed in the tailing to the cylinder for re-threshing.

Transparencies Nos. 9a and 9b

13. Cotton Pickers - Strippers

a. A cotton picker removes locks of seed cotton from the open cotton burr. It performs the type of work that is accomplished by hand. Pickers may be classified according to the way they are powered. There are cotton-picking units (one and two row) that are made to mount on tractors. The most modern type unit is self-propelled. The mechanical features of different brand names may be different. The main differences are the number of rows harvested, type of spindles, height of drums, and method of mounting pickers on tractors. The basic units of a picker are: the picking unit, fan delivery system, platform, controls, and the cotton basket. The principal parts of these units and their functions include:

(1) Stalk lifters, spring fingers, and grid bars move cotton stalks into the picking area.

(2) In the picking unit there are hundreds of spindles carried on spindle bars. Spindles rotate at 90 degrees to the direction of travel as they remove seed cotton from the stalk. A typical machine will have twenty spindles on each vertical bar. The bars are mounted on two drums (one on each side of the row). Spindles rotate and entangle and extract seed cotton from the open boll.

(3) Doffers remove the cotton from tapered spindles after they leave the plant. The stationary rubber face doffers drop the seed cotton so that it can be picked up by air from the conveyor. Cotton from straight spindles is removed by stripper bars as the spindle passes the bar. Doffers do not clean the spindles of dirt, plant sap, and other materials; therefore, the picking unit is equipped with moisture carrying tubes that deliver the water to rubber cleaning pads which clean the spindles.

(4) Cotton is conveyed to the carrying baskets by a fan that draws cotton from the drum through conveyor pipes. Dirt and trash are extracted from the cotton through grates by the air blast before it reaches the carrying baskets.

b. Cotton strippers remove cotton bolls from the plant. Plant leaves are either removed by frost or defoliation. Most strippers are made to harvest stormproof cotton. The two most commonly used strippers are: single and double roll and tine-type. Some types of strippers are mounted on the tractor, while others are pulled by a tractor.

(1) The major parts of a roll stripper may include: pick up grates or lifters, rolls or roll and bar, auger conveyor, pressure plates, fingerbeaters, fan, and conveyor chute.

(2) The major parts of a tine-type picker may include the following: pick up and stripping fingers, upper and lower beater conveyors, cleaner screen, auger, and conveyor chute.

References:

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3. Stone, Archie A. and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, New York, 1967

4. "Fundamentals of Service - Mowing and Spraying Equipment", Deere and Company, Moline, Illinois, 1974

5. "Fundamentals of Machine Operation - Tillage", Deere and Company, Moline, Illinois, 1976

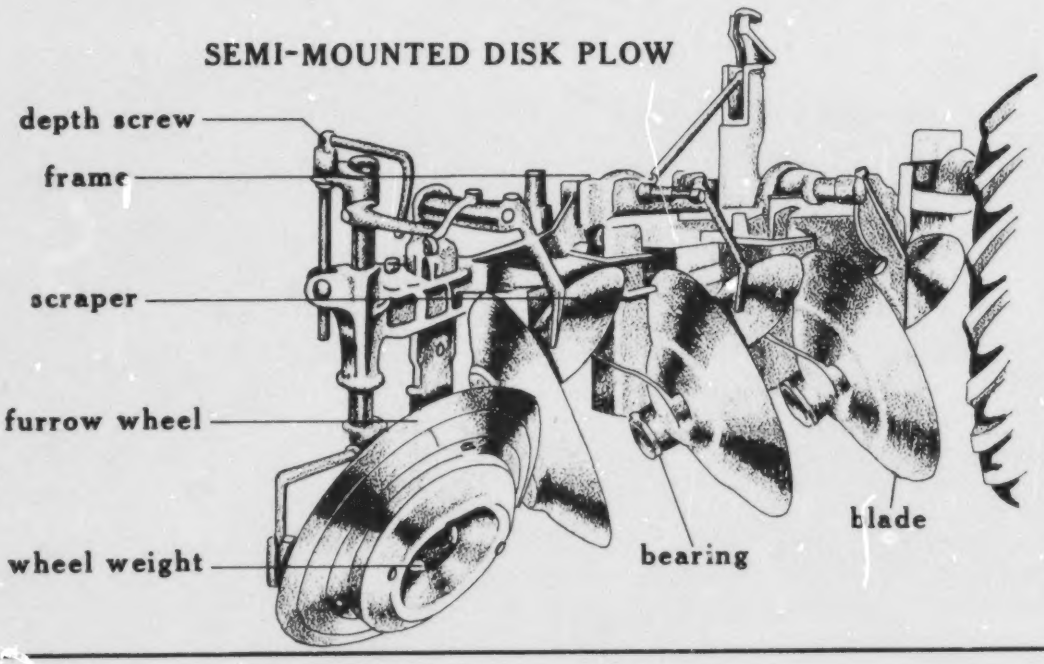
6. "Fundamentals of Machine Operation - Planting", Deere and Company, Moline, Illinois, 1975

7. "Fundamentals of Machine Operation - Combine Harvesting", Deere and Company, Moline, Illinois, 1973

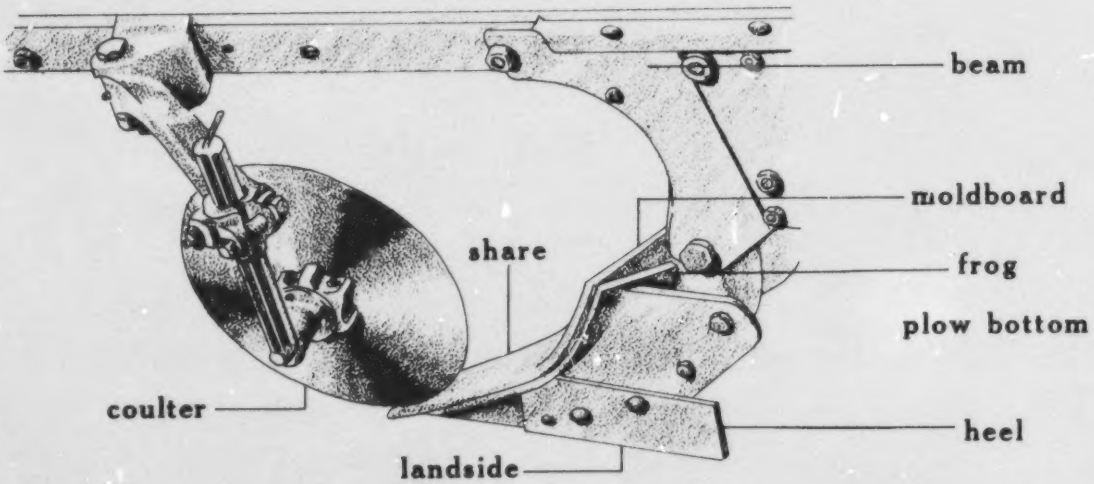
8. "Fundamentals of Machine Operation - Hay and Forage Harvesting", Deere and Company, Moline, Illinois, 1976

PLOWS

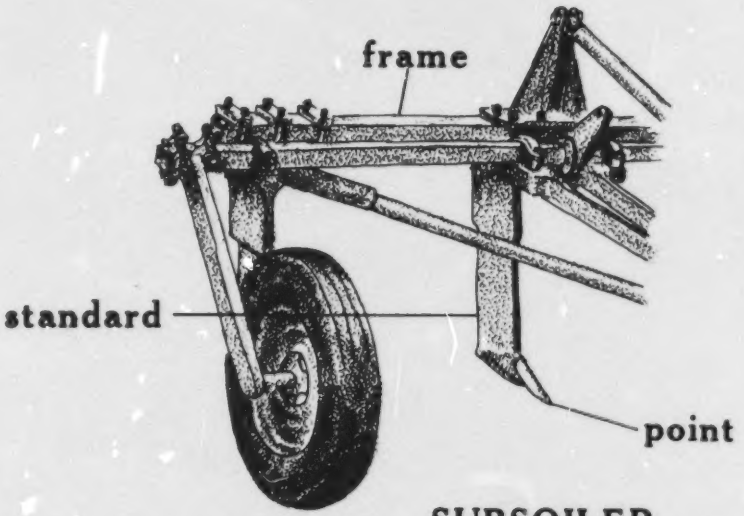
SEMI-MOUNTED DISK PLOW



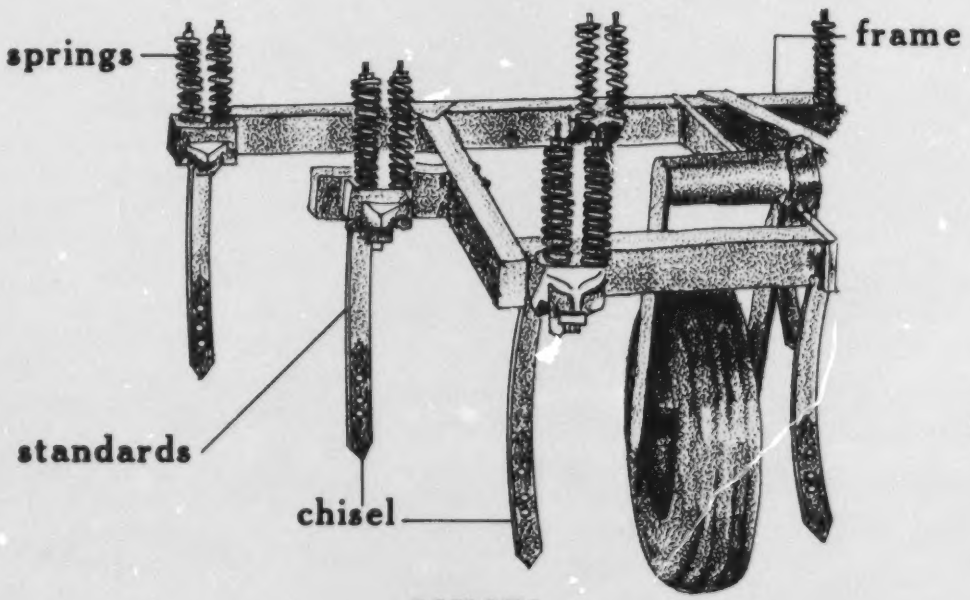
MOLDBOARD PLOW



PLOWS & PLANTERS

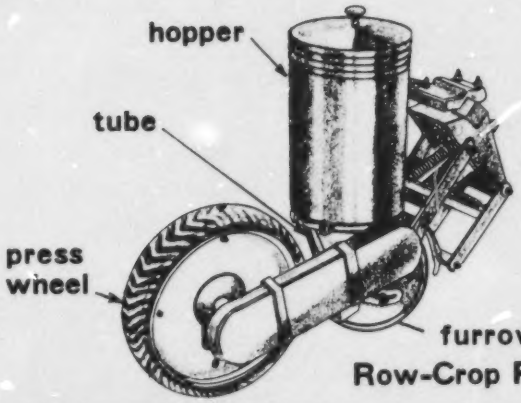


SUBSOILER



CHISEL

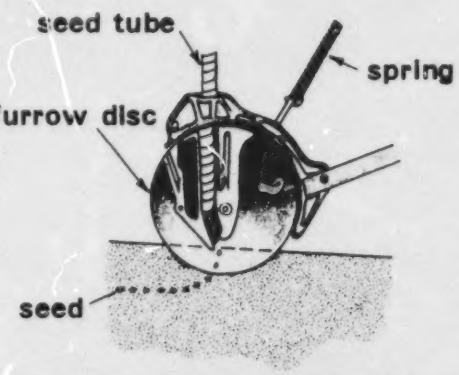
PLANTERS & DRILLS



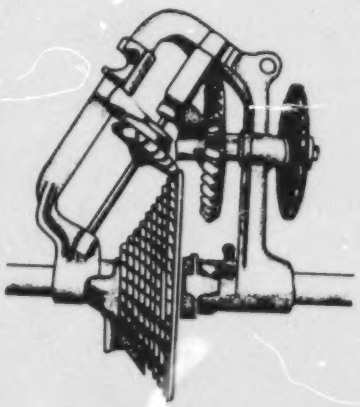
Row-Crop Planter

Small-Seed Side Double-Run Feed Cup

Single-Disc Seed Unit



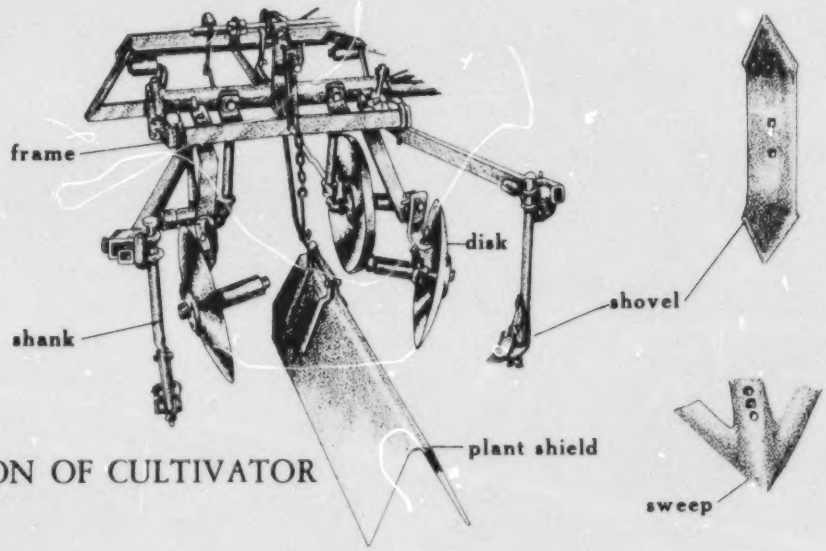
Speed Gears on Drill



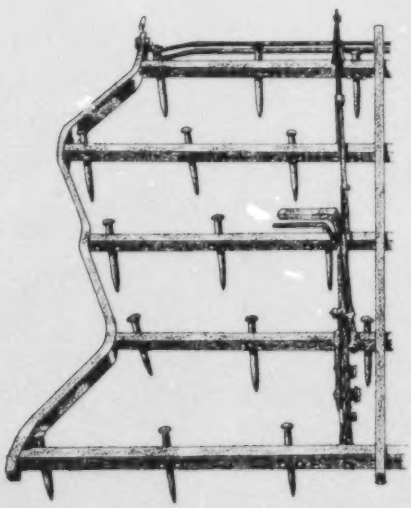
Furrow Opener

Correct & Incorrect

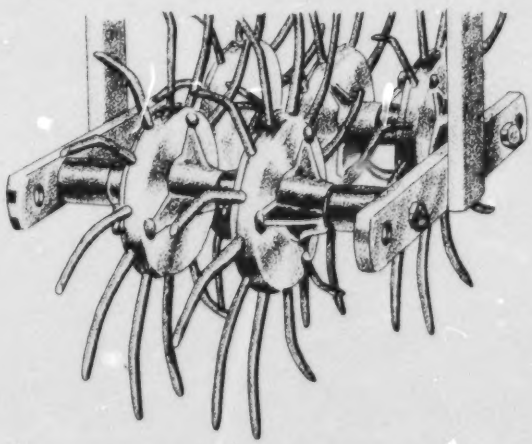
CULTIVATORS



SECTION OF CULTIVATOR



SECTION OF
SPIKE TOOTH HARROW



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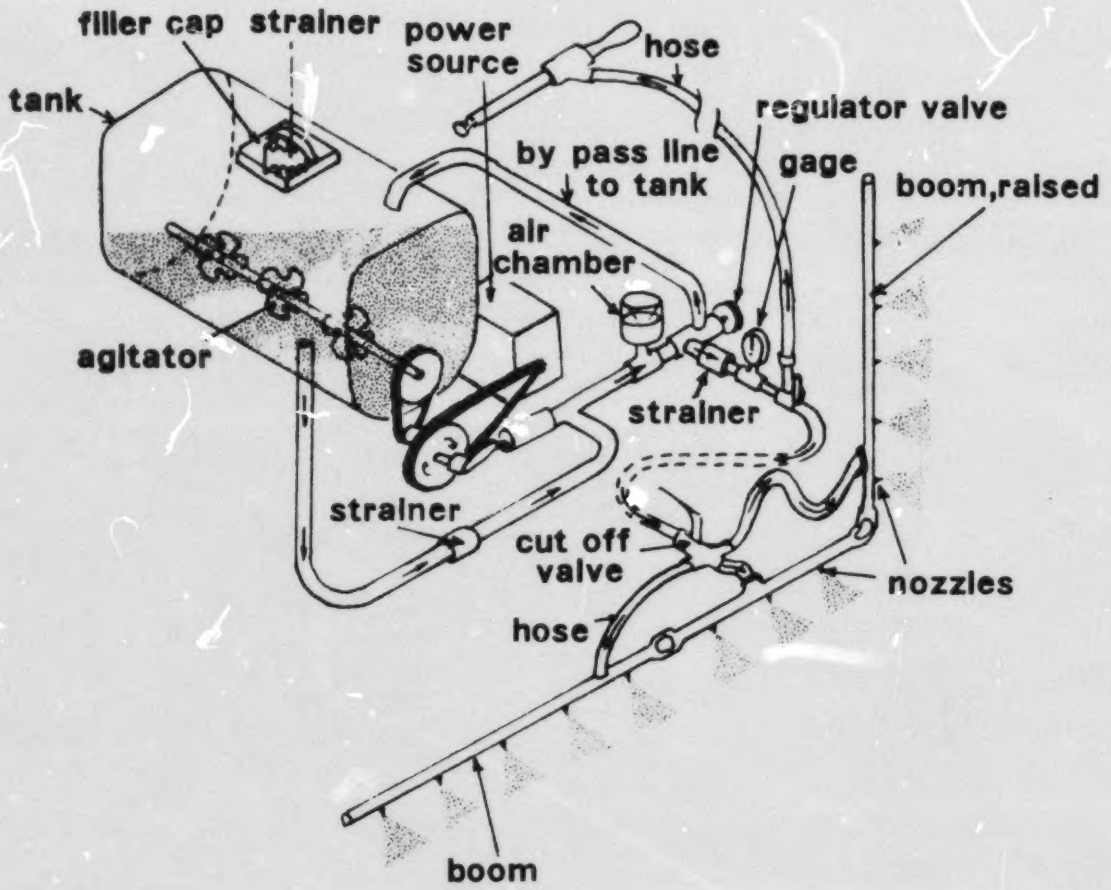
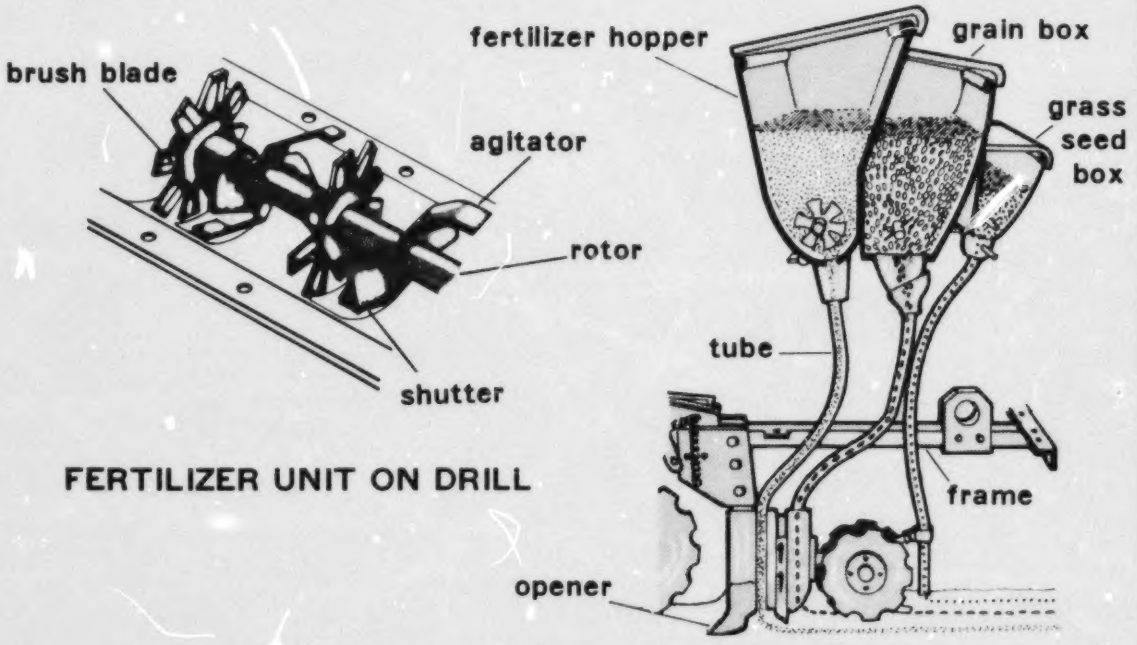
SPRAYER

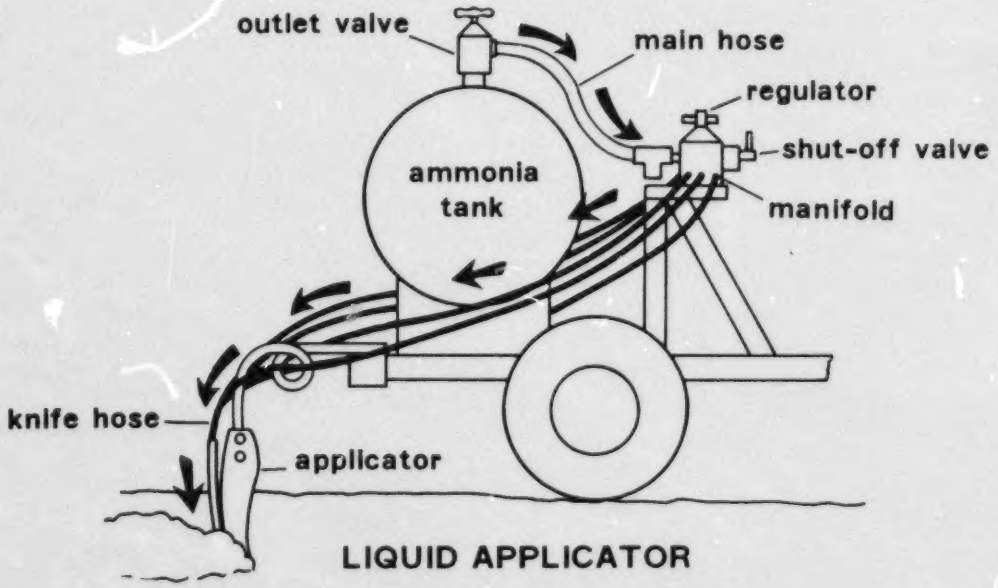


Power Sprayer

FERTILIZER DISTRIBUTOR AND APPLICATOR

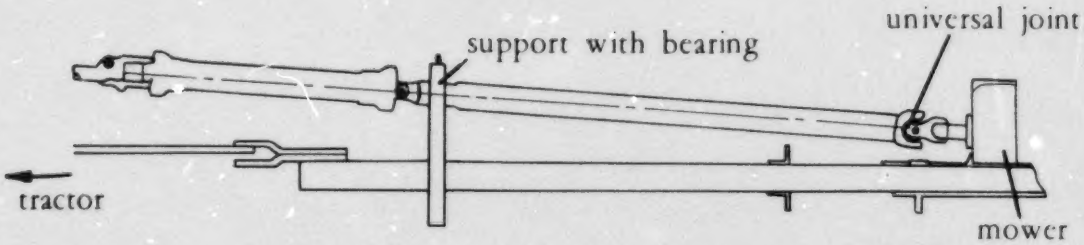


FERTILIZER UNIT ON DRILL



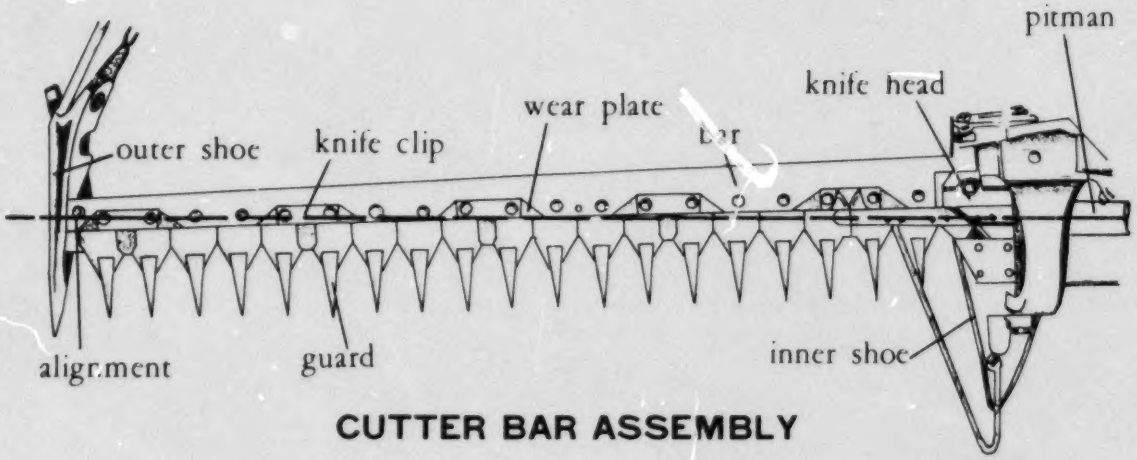
LIQUID APPLICATOR

MOWERS

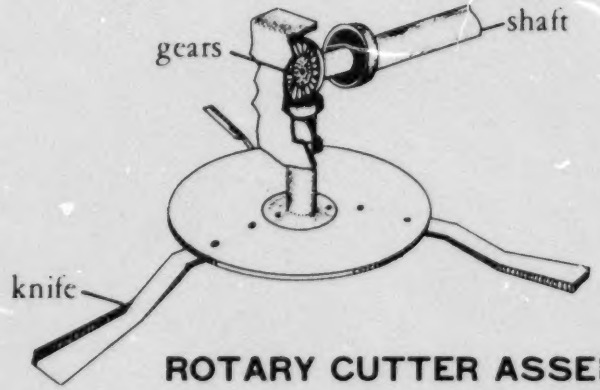


TRAIL TYPE MOWER

ROTARY CUTTER POWER TAKE-OFF SHAFT UNIT

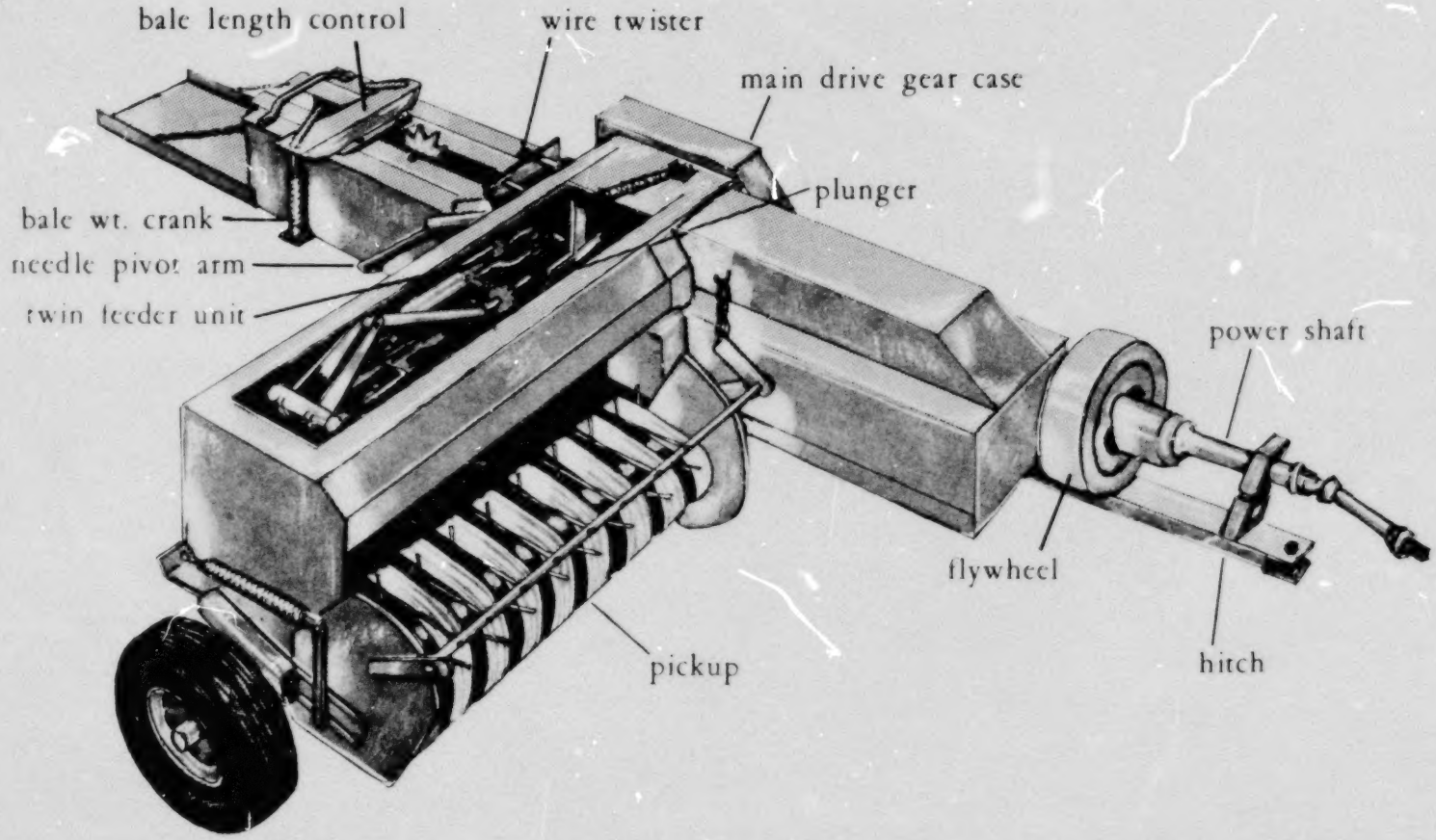


CUTTER BAR ASSEMBLY

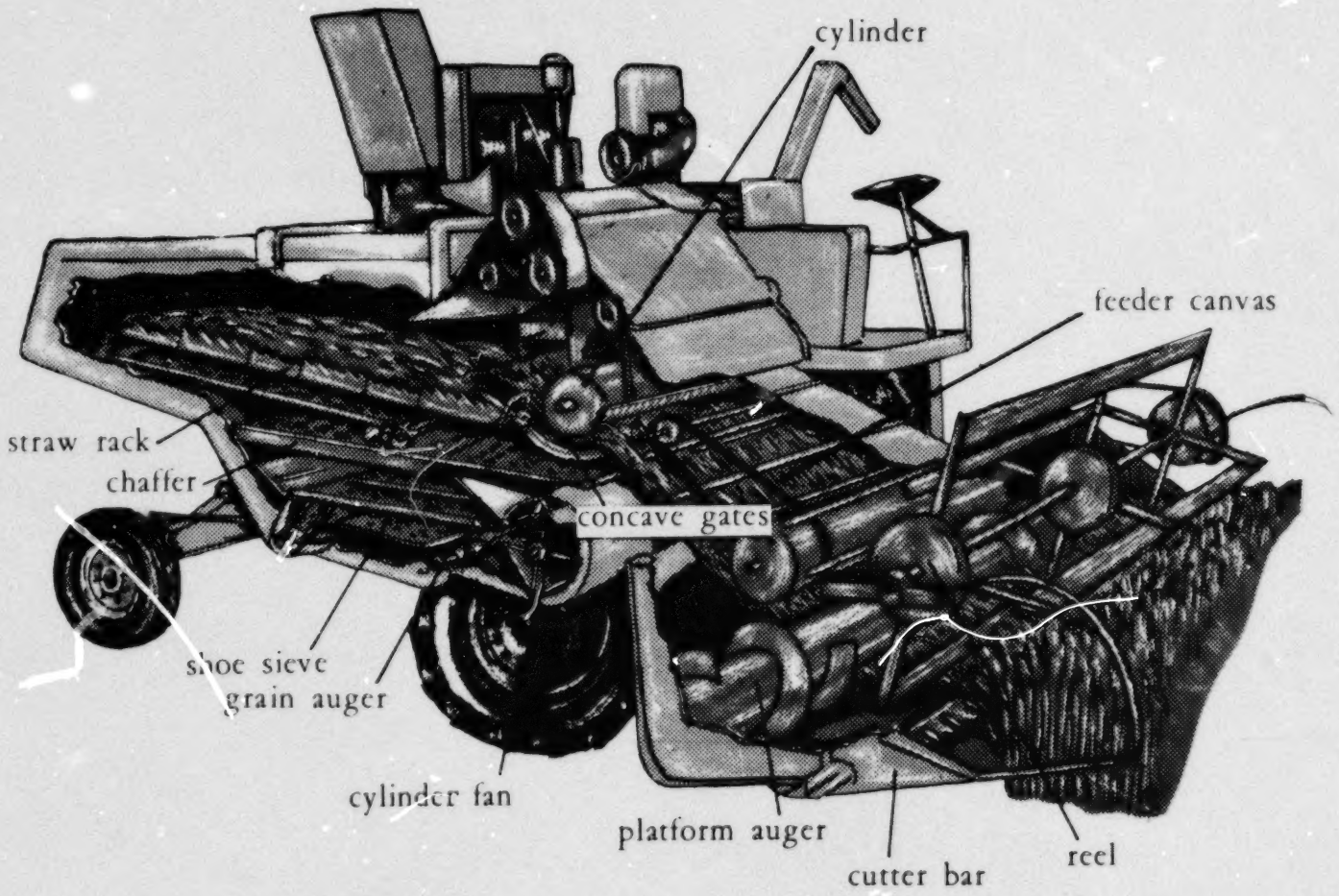


ROTARY CUTTER ASSEMBLY

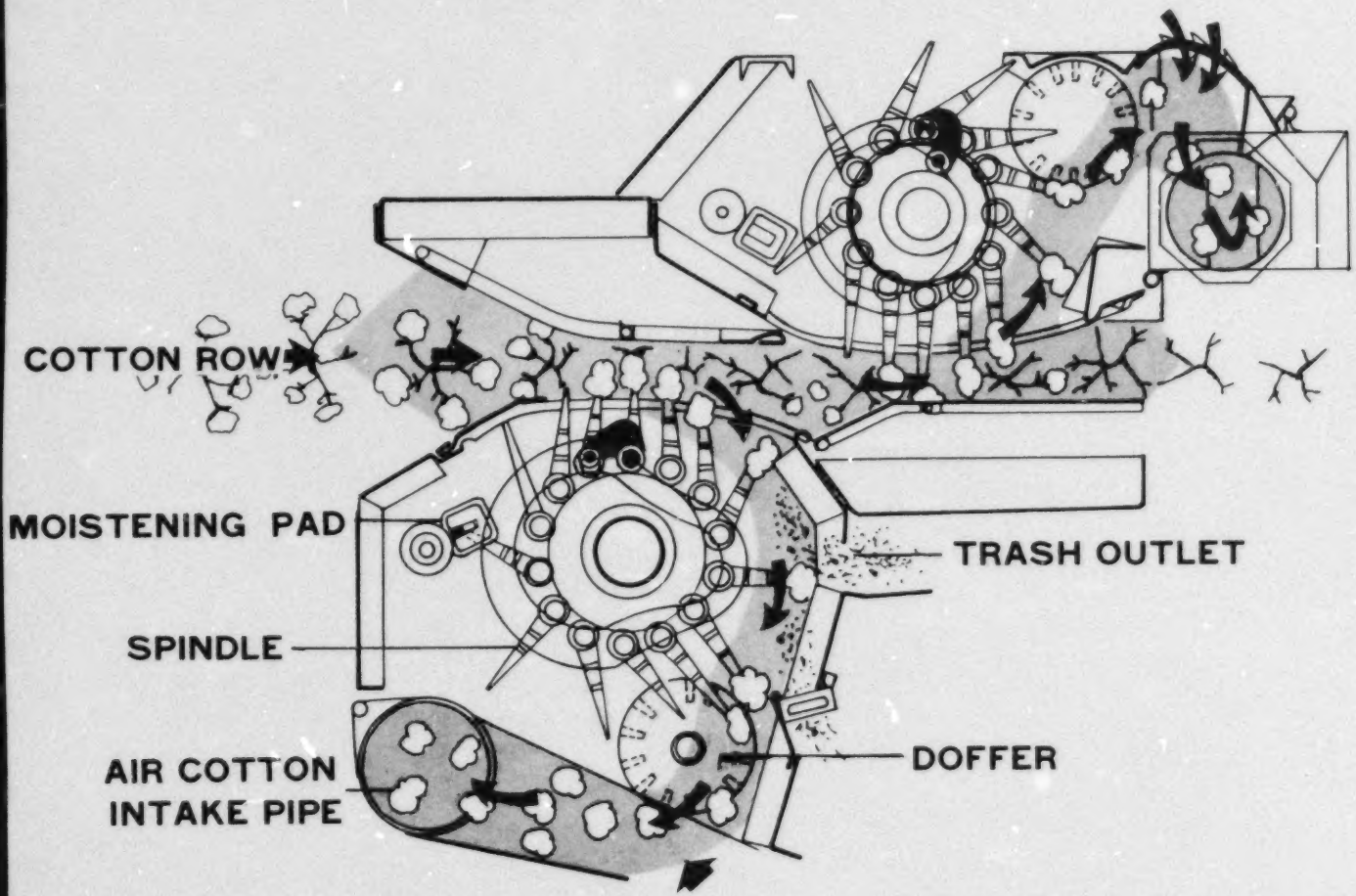
BALER


bale length control
wire twister
main drive gear case
plunger
bale wt. crank
needle pivot arm
twin feeder unit
power shaft
flywheel
pickup
hitch

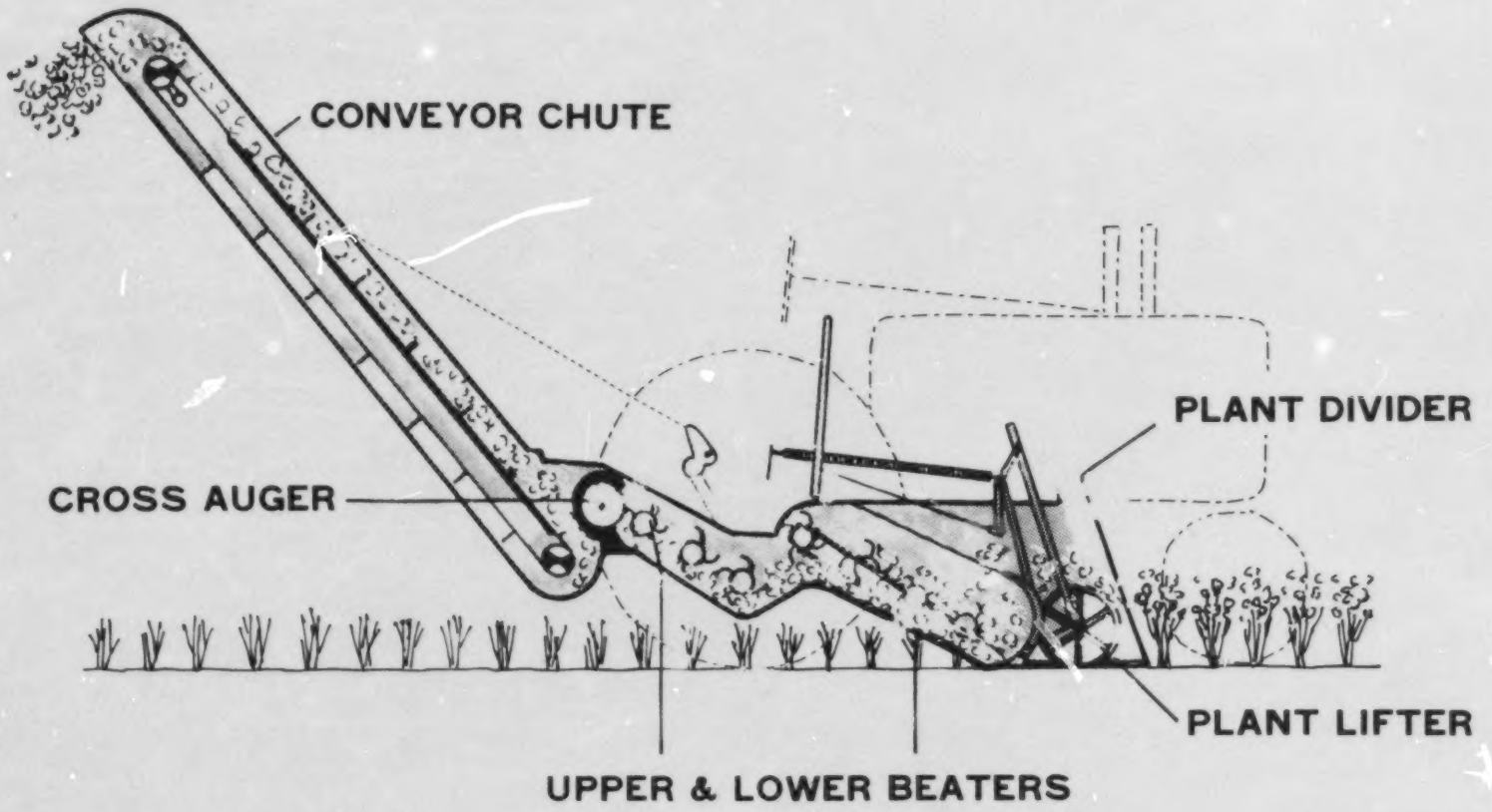
COMBINE


cylinder
feeder canvas
straw rack
chaffer
concave gates
shoe sieve
grain auger
cylinder fan
platform auger
cutter bar
reel

COTTON PICKING UNIT



COTTON STRIPPER



FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit D: Farm Machinery and Equipment

Topic 2: Inspecting Machines and Equipment

Suggested Procedures and Activities: After the class discussion move to the shop for a practice session on inspecting a plow, planter, cultivator, or grain drill. Use the inspection form to record the necessary information.

1. Why Inspect Field Machines

All machinery should be inspected periodically during the season or the period that it is used. A machine operator or owner should use a systematic procedure for checking the parts of equipment or machines. Farm machinery may be inspected anytime throughout the year, but the more desirable period for inspection is at the close of the working season. The major reasons for inspecting the machine at the end of the work period are:

a. Adequate time is needed to make a thorough inspection.

b. It may be necessary to replace worn or damaged parts. Also, it may be necessary that the dealer order parts from the manufacturer.

c. The machine should be thoroughly cleaned. This operation should not be a hurried up type of job.

d. Major repairs may require several weeks to complete; therefore, the machine should be inspected immediately at the end of the working season.

2. Procedures Used When Inspecting Machines

Transparency No. 1

a. Some owners and some operators of farm machinery use a special inspection form in order to list all information necessary for making machine repairs. This form contains the following information:

Name of Machine	Condition of Parts or Assembly
Make of Machine	Name of Part or Assembly
Model and Type of Machine	Type of Work or Job
Date of Inspection	Part or Parts Needed

Catalog Number

Inspection forms are usually available from the Agricultural Extension Service and from machinery dealers.

b. Things to check on the more important field machines are:

Disk Plows, Tillers, and Disk Harrows - When making the inspection, check the disk cutting edge for sharpness, bearings for wear, disk cleanliness, looseness, springs for tension, scrapers for adjustment, and frame parts for distortion.

Moldboard Plows - Inspect the plowshare for sharpness and the plow bottom and side for suction. Check furrow wheel bearing, plow beams, braces, hitches, pivots, and linkage for wear and/or distortion.

Chisel Plows and Subsoilers - Look for bent teeth, bent shanks, and bent frame parts on chisel plows and subsoilers. If the plows are on wheels inspect wheel bearings for wear and proper lubrication. Inspect wheel bearings for wear and proper lubrication. Inspect the paint on the frame.

Planters - Inspect the parts of the hopper. All gears, chains, and sprockets should be checked. Inspect cut-off and knockout pawls, bottom rings, and spring tension. Inspect the valve mechanism and furrow openers.

Cultivators - Inspect all parts of the tractor-mounted cultivator for wear. Check shank release (spring, friction, and pin-break) for adjustment. Inspect sweep or shovel cutting edges for sharpness, and check spacing of sweeps or shovels.

Sprayers - Sprayers usually receive better care than other machinery due to their being cleaned after each job. Fertilizer distributors are also cleaned after a job. Sprayers can be easily damaged by chemicals if they are not properly cleaned and inspected immediately after use. The following parts of a sprayer should be checked: nozzles, pressure gauge, belts, pulleys, bearings, hose and pipe connections, agitator, tank, hand gun, valves, strainers, and pump. Check parts that require lubrication.

Fertilizer Distributors, Applicators, and Manure Spreaders - Inspect the hopper for rust areas caused by fertilizer deposits. Check center and wheel bearings for wear and proper lubrication. Inspect the rotor and feed shutters for free movement.

A fertilizer applicator, like many other field machines, must be checked or inspected before and after use. Inspect the valves and hoses for leaks. Check the metering devices to determine if they are functioning under the proper pressure. Inspect wheel bearings for wear and lubrication. After using the

applicator inspect the tank to determine whether or not it contains ammonia.

Most manure spreaders are equipped with chain conveyors; therefore, check the chains for proper tension. Inspect all sprockets and bearings for wear. Check beater knives and the spread beater for damage.

Tractor-Mounted Mowers - Check the mower knives for a proper cutting edge. Check for proper knife register in the guards. Inspect the wrist pin, bearings, and flywheel for wear. If the mower is equipped with a pitman check the wear; check pitman lead and lag. Check the bolt for wear in a pitmanless drive mower. There are many other check points on a mower. Some are: the guard alignment, knife straightness, knife head bushing, knife rivets, guard ledger plates, guard lip clearance, adjustable wear, plate, drive pulley on pitmanless mower, and vertical and side play at knife head. Examine the cutter bar assembly for wear.

Rotary Mowers - Check the knives for proper cutting edge, excessive wear, nicks, and straightness. Examine all nuts and bolts for tightness. Check the drive shaft and bearings for wear and adjustment. Check for proper clutch action.

Balers - Balers have many moving parts, and each part serves a very important function for proper machine operation. It is important that the machines be carefully checked throughout the baling season. A frequent inspection should include the following:

Check all belts and chains for correct tension, wear, and alignment.

Check pulley and sheaves for alignment.

Check bearings and sprocket teeth for wear.

Check the entire feeder unit for wear and damaged parts.

Check plunger speed and the plunger and slide blocks.

Check the cutting edge and clearance of the slicing knives.

Check the weight and density of the bales.

Check the entire tying mechanism.

Rakes - Inspect the rake frame, tooth bar, strippers, teeth, and reel ends for damage. Most rake damage is caused by springing or bending certain parts. Check the bearings for wear and proper lubrication. Some rakes are equipped with enclosed drive gears that should be checked often.

Combines - Combines are similar to hay balers, in that they are made up of many moving parts. Some parts may work independently of each other, but if the machine is to operate properly, all parts in each mechanism unit must be in good condition at all times. An inspection of the combine will include the following jobs:

Check for worn and loose chains, sprockets, belts, and bearings.

Check the canvas for tears and check for loose or broken slats.

Check for auger straightness and wear.

Check a spike-tooth cylinder for bent, broken, and worn teeth. Also check the cylinder RPM.

Check for loose rivets and bolts on the straw rack.

Check for holes in the grain pan, dents in the sieves, and bent air fan valves.

Check the elevator and augers for damage.

Cotton Pickers - Cotton harvesting equipment has many moving parts, and some of the basic parts require continuous checking. Some of the inspection jobs are:

Check the spring fingers and stalk lifters for damage. Also check the position of the grid bars on certain types of pickers. Spindles may strike bent bars.

Check spindles (tip barbs) for wear. Cotton picking efficiency depends largely upon the spindle.

Check the picker bars by trying to force them up and down and in and out. Examine all needle and sealed gears on spindle drive shaft.

Check the drum drive shaft gears for wear. Also check the drum bearings.

Check the doffer shaft for straightness. Inspect the O-ring for wear and check for lubrication. Inspect all spline and sprocket teeth for damage or wear. Also check all drive chains.

Check the moistening system for possible water stoppage. Check the hoses for splits, kinks, and corrosion. Check the distributor head for corrosion. Inspect water holes in moistening pads. Also check water lines for leaks.

Check the fan rotor for cracks in blade welds. Check the fan bearings and seals for wear. Check fan for dents.

Check all gears, bearings, chains, pulleys, and sprockets for wear.

Cotton Strippers - The first cotton strippers were very simple pieces of farm equipment. They appeared in the form of a sled with either fingers or rolls that removed all bolls from cotton stalks. This type of stripper required simple maintenance. Modern strippers require about the same maintenance practices that are used on cotton pickers. Stripper inspection jobs are:

Check the plant dividers for dents and bends.

Check the pickup fingers and limb lifters for breaks and bends.

Check the stripper rolls on the roll type for straightness, corrosion, and dents.

Check the conveyor beater fingers for straightness and inspect the finger drums for cracked or bent parts.

Check the auger or augers for straightness and dented blades.

Check all bearings, sprockets, gears, chains, and belts for excessive wear. Check the tension of belts and chains.

3. General Inspection Procedure Used on all Machines and Equipment

If the machine is equipped with tires, they should be checked for wear and general condition. Machine parts that require oil or grease should be checked for proper lubrication. Machines are painted in order to protect the material against heat, moisture, and chemical reaction and to improve appearance. When inspecting the machine at the end of the working season, the paint should be inspected to determine if it is cracking, checking, peeling, and/or chalking.

4. Inspection Periods

There are actually three inspection periods for field machinery, assuming that the machine or equipment is already assembled. The inspection periods are:

Attachment or Prefield - All machines are prefield inspected at the time the machine is hitched or mounted on the tractor. Inspection may include only the

hook-up connections or it could include checking lubrication, loose parts, distortion on certain parts, and machine alignment.

Field - Usually field inspection includes the proper function of the machine and its parts. This inspection period is used to make operational adjustments. The second check for alignment is performed at this time. Other things that are checked are: the rate of seeding, correct plow setting and depth of operation, the weight and density of bales of hay, the function of the spray nozzles or nozzle, and the loss of grain when combining.

End of Operation - The end of operation inspection period is used mainly to inspect parts for repair or replacement. This period is also used to check parts for major adjustment. In general, it is the period to inspect the machine for reconditioning. The life of the machine may be prolonged if a thorough end of season inspection is carried out for reconditioning.

End of operation inspection should involve field inspection; the machine must be in operation in order to determine its operating condition. Such conditions as worn bearings, machine vibration, uneven drag, seed distribution, sprayer pressure, and loss of grain from a combine are more easily detected if the machine is in operation.

A record should be made of any malfunction, explaining the condition in detail before the machine leaves the field for the season. This machine record should be used when reconditioning the machine.

References:

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Danville, Illinois, 1967

2. Stone, Archie A., and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, New York, 1967

INSPECTION

MACHINERY INSPECTION FORM

Machine _____ Date _____

Make _____ Model _____

Name of Part	Condition of Part	Type of Job	Part Needed	Part Number

Detail Information

FARM POWER AND MACHINERY MAINTENANCE AND REPAIR

Unit D: Farm Machinery and Equipment

Topic 3: Reconditioning

Suggested Procedure and Activities: Worn parts such as belts, chains, bearings, plowshares, mower knives, and blades, sprockets, and gears may be helpful as teaching aids during the class discussion.

1. General Practices for Reconditioning Machinery

There are four major practices involved in the reconditioning of most farm machines. The practices are:

a. Cleaning - Even though cleaning of machinery is considered a pre-inspection practice, it may also be recognized as a major reconditioning practice. Harvest and spraying machines are cleaned frequently, due to the nature of work they do and the parts that require maintenance. Cleaning may be done with a cleaning solution, water, air, and solvents.

b. Lubrication - Proper lubrication keeps the machine restored to the desired operating condition. All machines require some type of lubrication. The operator's manual is the best guide to follow when lubricating a machine.

c. Tightening Loose Parts - Most machines consist of parts joined or held together by bolts, cotter keys, set screws, and other locking devices. Bolts, nuts, screws, and cotter keys may be loose, broken, or lost during the time the machine is in operation. Bolts and nuts that do not come off when using ordinary methods may be heated with a gas torch.

d. Painting - If a machine is properly reconditioned, all parts subject to rust will be covered with paint. A machine is easier cleaned if it carries a good coat or two of high quality paint. Paint helps protect the metal against chemicals that cause corrosion.

The machine inspection sheet and the operator's manual should be referred to before undertaking a reconditioning job.

2. Reconditioning Disk Plows, Tillers, and Disk Harrows

a. Replace lost or broken parts of the machine with new or good used parts. Certain broken parts may be welded. Straighten bent and twisted parts. It may be necessary to remove bent frame parts in order to make the repair.

b. Replace bearings that are worn too much for proper adjustment. Replace bushings in the roller type disk if they are worn and cannot be tightened snug. Replace worn ball-and-socket gang joints.

c. Follow the recommendations in the operator's manual when sharpening the disks. Most disks are sharpened by either grinding the vertical edge (inside) or turning the edge on the convex side by a special machine.

d. Replace any broken, bent, or weak springs found on the disk plow. Most modern disk plows are free of springs, except near the depth wheel or wheels on some models.

e. A worn or damaged ratchet lift should be replaced or repaired. A damaged or leaking hydraulic lift unit should be repaired. If the ratchet lift threads become damaged, it may be advisable to replace the lift.

Any part of the disk that is disassembled should be reassembled in the reverse order. After the machine is reassembled, test all nuts and bolts for tightness.

3. Reconditioning Moldboard Plows

a. Remove plowshare and sharpen by grinding the share point on the top side. If welding equipment is available, the share edge can be made to last longer by hard surfacing.

b. If the plow is equipped with a coulter, it should be disassembled and sharpened by grinding both sides of the disk.

c. Wheel and coulter bearings that are worn or have damaged caps and shells should be replaced. If the axle is worn, it may be replaced or reconditioned with a weld and ground to the proper size.

d. Straighten or replace parts of the plow frame that are sprung or bent. Most damaged plow beams are replaced due to the lack of proper equipment to straighten the beams. Integral-mounted plows (tractor mounted or tractor carried) have one beam for several bottoms. If any part of the frame or steering mechanism becomes bent or sprung, it should be replaced.

e. Replace badly worn landsides, moldboards, and plowshares. Broken landsides and moldboards may be welded and the welded area ground smooth.

f. Repair the power lift mechanism (hydraulic unit) if leaks appear on the cylinder or hose. Replace parts of the unit that cannot be repaired.

4. Reconditioning Planters and Seed Drills

a. Remove runners and disk if they appear dull. These parts may be sharpened by grinding.

b. A bent or twisted frame may cause the runners to be at a different distance from the ground. Straighten the bent or twisted metal with a hammer.

c. Replace weak or broken springs. Replace worn bearings and bushings. Replace worn sprockets and chains.

d. If the valves appear sluggish or worn, replace them. If new hinge pins are needed, drill larger holes for the new larger size pins. Worn valve rods should be replaced.

e. Consult the operator's manual for timing the seed plate driving mechanism. Some planters have timing marks that can be used to set the timing.

f. Usually it is not necessary to replace the drill shaft and clutch, but if a clutch dog is badly worn it may be necessary to replace the part.

The grain drill is repaired in about the same manner as repairing the rowcrop planter, except for the hopper mechanism.

g. Replace weak or broken springs. Compression springs that hold the dragbar and furrow opener in the ground may lose tension due to frequent adjustment and use.

h. Remove the disks and sharpen them if they seem dull. Damaged furrow openers should be replaced. Damaged or worn furrow opener parts should be replaced. Replace damaged seed tubes.

i. Replace bearings that are worn or damaged. Also, replace chains and sprockets that fail to function properly due to wear or damage.

j. Worn or damaged parts of the feed mechanism must be replaced if the drill is to sow seed properly.

k. If the frame is bent or the hopper dented, these parts should be repaired. It may be necessary to straighten the frame and weld angle iron over the damaged area.

5. Reconditioning Cultivators

a. Repair or replace frame parts that are sprung, twisted, or broken. Broken frame parts can usually be repaired by welding.

b. Sharpen dull shovels, sweeps, disks, and cultivator teeth. If the points of shovels, sweeps, and teeth are not worn beyond repair, they may be reshaped by heating and drawing the point out and then grinding it.

c. Weak and broken springs should be replaced if the cultivator is to function properly. Some cultivators are equipped with trip and compression springs.

d. On cultivators that are equipped with wheels, replace the wheel bearings and wear sleeves that are damaged. It is necessary to install new bearing seals when removing the wheels. On some models of rotary hoes, the bearing resembles a section of pipe with a mounted grease jet. The bearing should be replaced if it becomes worn. It may also be necessary to replace or build up the shaft.

e. Repair crop shields by removing the dents and bends in the metal. Replace the pair of shields if they cannot be repaired so that they will travel evenly in the row.

6. Tractor Mounted Mowers

a. Remove and straighten the knife assembly by using a hammer and anvil, or replace it in a vise and bend it the proper direction.

b. If it is necessary to remove broken or worn teeth, place the knife section in a loosely closed vise and strike those blades that are to be removed with a hammer. Install new blades on the knife bar.

c. Grind blades on a leveled grinding wheel. Replace blades that are ground to a point and replace those that are broken or damaged.

d. Replace guards that are sprung badly. The guards may be sprung up, down, and to one side. Replace the wearing plate, ledger plate, knife chips, and guards if they show excessive wear. Replace ledger plates in one operation.

7. Reconditioning Rotary Mowers

a. Remove knives from mower if they cannot be sharpened on the mower. Knives may be attached to a knife holding strap by pivot bolts. Most mower blades may be sharpened without removing them from the shaft.

b. Grind the beveled edges by placing the knife lightly against the emery wheel.

c. Most rotary mowers are equipped with needle, roller, and ball bearings. Replace the old worn bearings with new ones.

d. Some mowers are equipped with a telescoping drive shaft. Replace the shaft if it is slightly out of line. A bent shaft will cause vibration.

e. Worn or damaged universal joints should be replaced or repaired. The universal joints may be either the external snap ring or the internal snap ring type. Usually a universal joint can be repaired with a replacement kit.

f. Remove and replace old shear pins. Replace slip-type driveshaft clutches that do not function properly. The plate type clutch may have worn disk plates, and the ratchet type clutch may have damaged teeth.

g. Replace worn belts and springs. Also, replace belts that are cracked and/or frayed and replace those that continue to stretch.

h. A rotary mower is equipped with a beveled gear. Replace both gears if one is damaged. Install new backlash-adjusting shims so that the gear fits properly in the housing when the retainer is tightened against the shims.

8. Reconditioning Balers

Most baler difficulties are corrected by proper adjustments, but some operation difficulties must be remedied by repair or reconditioning. The baler must be reconditioned before it enters the field. Some major reconditioning jobs are:

a. Repair or replace pickup teeth. If pickup teeth are not revolving, tighten or replace the drive belt.

b. Replace worn or broken parts in the wire tying mechanism. Replace the wire-guide rollers if they fail to rotate freely. Replace or repair wire shear plungers. Remove grooves that have been cut by wire on the plate behind twister pinions with a file.

c. Replace the twine billhook if the twine knot cannot be tied tightly. Replace the other tying mechanism parts that are bent, broken, or worn. The billhook may be made smooth by filing; this will eliminate twine hanging on it. Sharp edges found on the disk and twine holder should be removed with emery cloth. Sharpen the twine knife if frayed ends appear at the knot.

d. Sharpen the slicing knives to give a clean cut bale. The knives may be sharpened with a file on the machine. Some machines have a built-in sharpening mechanism. On some baler models the knives are removed for grinding.

e. Replace release arm or trip dog spring if the needles do not rise.

f. Replace worn gears, belts, sprockets, chains, and springs. Most balers are equipped with many of these power transfer parts.

9. Reconditioning Combines

Usually more time is needed to recondition a combine than any other machine. Reconditioning practices are:

a. Replace worn belt and bearing on the reel. Replace damaged reel bats.

b. Repair and recondition the cutter bar in the same way that a cutter bar is reconditioned on a mower.

c. Replace the slats or teeth in the feed conveyor. Some models may use a canvas which must be replaced periodically.

d. Replace the rub-bars if the grooves are not present. In order for the cylinder to remain in balance, all bars must be replaced at the same time. Bent bars may be straightened with a hammer.

e. Straighten the teeth and spike-tooth cylinder with a steel bar. Replace worn, broken, and pointed teeth. Spike tooth concave teeth are usually straightened with a hammer. Broken concave bars must be replaced. The space between the concave and cylinder teeth is recommended in the operator's manual.

f. Remove straw racks and replace those that are worn or broken. If racks are not too severely damaged, they may be repaired. Replace rivets and bolts that have worked loose. The continuous vibration of the rack works rivets and bolts loose. Replace the check flaps if they appear worn.

g. Straighten bent fingers on the chaffer. Broken or damaged slats on the cleaning mechanism should be replaced.

h. Remove dented sieves and straighten the dents with a hammer. Bent valves on an air fan should be straightened.

i. Replace grain pans that have holes in them. It is a difficult job to repair a damaged grain pan.

j. Due to the fact that combines have more belts, bearings, chains, gears, and sprockets than most farm machines, much of the reconditioning time should be devoted to examining these parts and replacing the ones that show wear or damage.

10. Reconditioning Sprayers

a. Disassemble the sprayer and unclog nozzles with a wood probe. Replace

those nozzles that fail to function properly. Replace or repair a slightly bent boom.

b. Remove the old strainers and replace them with new ones. Replace damaged lines, hoses, valves, and gauges.

c. Usually it is not necessary to replace the pump. If the sprayer system loses volume and pressure, it may be necessary to replace the pump, unless the lines are clogged.

d. Brass fittings and nozzles are usually stored in oil to help prevent corrosion.

11. Importance of Cleaning

a. Cleaning is the removal of various forms of soil, sand, grease, oil, tar stains, and many types of film. Most forms of dirt can be removed by washing, sweeping, and shoveling. When mechanics is applied to a cleaning operation, water under pressure, vacuum, and power brushes are used.

b. There are three types of dirt found on most engine surfaces. They are:

(1) Loose Dirt - Usually loose dirt can be removed by water under pressure, vacuum, and power brushes.

(2) Adherent Dirt - The removal of adherent dirt requires the use of heat and a type of solvent or detergent or both in addition to using brushes with water.

(3) Invisible Dirt - This type of dirt is removed by suitable heat, chemicals, or a combination of the two. Invisible dirt must be removed from an engine before it is painted.

c. Cleaning or removing adherent dirt requires a factor balance of four factors. For example, the best way to remove dirt from the hands is to use warm (heat) water, soap, and friction. When soap is applied with warm or hot water, the hands rubbed, the surface tension is broken releasing the dirt. If grease is present, an emulsifying action takes place (soap particles surround a particle of grease and move it away). If a soap containing alkali is used to remove animal fats or vegetable oils, a chemical reaction (saponification) takes place. Free alkali combines with the fat, forming a soap. The four basic factors used in steam cleaning are:

(1) Soap - The amount of soap used to clean an engine or machine is regulated by the form and amount of dirt present; therefore, soap can be considered a variable factor used for cleaning.

(2) Heat - Heat actually increases the power of soap. Various surfaces require different temperatures.

(3) Water - Soap and heat are carried to the dirty areas by water. Dirt and soap are removed by the water.

(4) Friction - When washing the hands, they are rubbed together causing some friction. The use of a brush or abrasive power will cause even more friction. When cleaning an engine, friction may be caused by pressure or force.

d. Proper cleaning of a machine and its parts adjacent to the engine is one of the most important jobs that can be performed while repairing or overhauling the engine. Improper cleaning usually means an improper overhaul or repair job. If the engine and its outside parts are to be painted, the surface must be clean in order for the paint to adhere to it.

e. Precleaning or cleaning before the engine is disassembled is absolutely necessary to prevent contamination of parts during the teardown. After the engine is dismantled the parts can be cleaned.

f. It is true that a dirty engine may show oil and water leaks before it is cleaned, but it is easier to pin point these areas if the engine is clean. For example, leaking core plugs or cracks on a diesel engine may be located by rust leaks. These rust areas cannot be found on a very dirty head and engine block.

g. Reconditioned or new engine parts should never be replaced on dirty greasy parts. Such parts may become contaminated immediately after installation or fail to fit snug even though gaskets are used.

Transparencies Nos. 1 and 2

12. Cleaning Methods

a. Steam Cleaners - Steam cleaners were the first cleaners used to clean engines and machine parts. A steam unit consists of a heat unit (oil or gas) that forces heat through a number of coils generating steam

pressure from the water, flexible steam hose, and a steam gun. In some units the cleaning solution is fed directly to the gun, whereas in other units it is mixed in the cleaning solution. Steam without a steam cleaning compound is a hot, soft, gasified fluid lacking mass. It is similar to a sand blast stream without the sand. It is used in the following manner:

(1) The water and water pump are turned on to fill the coils with water. This step is followed by igniting the burner.

(2) The solution tank is checked and stirred, or steam pressure is foreced into the solution by the gun.

(3) Cleaning solutions may damage the carburetor, generator or alternator, and distributor; therefore, these areas should be covered or protected during the cleaning process.

(4) Prolonged steaming should be avoided in and near the electrical system. And, it is recommended that air conditioning lines not be steamed.

(5) Usually a gun nozzle is held one to four inches from the object being steamed. A "wet" or "watery" steam is recommended for cleaning.

(6) Safety rules to observe when steam cleaning are:

(a) Work must be well ventilated.
(b) Steam cleaner should be grounded.
(c) Pressure should be in proper limits and the work area free of personnel.
(d) Face shield should be worn to protect face and eyes from splatters.
(e) Directions in the instruction book should be followed when operating the machine.

b. Hot Tank Cleaner - Hot tanks are used for heavy cleaning. A strong alkaline compound is usually mixed with water and the solution heated from 180 to over 200 degrees F. If aluminum parts are cleaned in the hot tank, the caustic solution should be weakened. After all parts are taken from the tank, they should be washed thoroughly. Parts that may rust must be oiled. Any part that may contain the solution, such as water jackets or oil galleries, should be thoroughly flushed out with hot water. The most commonly used cleaner compound for hot tank cleaning is a detergent.

c. Pressure Spray Cleaning - The two types of pressure cleaning are high

(up to 500 pounds per square inch) and low which requires a small amount of pressure. Both methods (high and low pressure) require that a soft mist of detergent or other cleaning solvent be sprayed on the object as the first cleaning step. After dirt deposits soften, the high pressure gun may be used to remove dirt using a fan shape stream of water and adjusting to a narrow stream at high velocity for removing dirt in corners. The low pressure gun is usually used to spray a solvent (kerosene, detergent, or other nonflammable solvent) on the object and it is later washed with water. Even though high pressure cleaning may be done with cold water, some manufacturers have models with a heating coil so that water may be heated to about 160 degrees F.

d. Cold Soak Cleaning - A cold soak tank is usually used to soak parts. The parts are placed in a container (basket) and soaked for several minutes before they are removed and rinsed with a solvent or water. It may be necessary to dry the parts with an air gun, but most of the time they are wiped dry or allowed to dry after rinsing.

e. Ultrasonic Cleaning - This cleaning method is considered new. A generator is used to convert the electric current into electric energy which has a high acoustical frequency. The unit is equipped with a transducer that makes a conversion of electric energy to mechanical energy. The high frequency sound waves form partial vacuums in the cleaning liquid which is moving very swiftly by agitation. Dirt particles are removed by the cavitation blasts.

f. Special Parts Washer - A cold solution parts washer is a much more efficient way to clean parts than washing and soaking them in buckets or cans. Most washers are equipped with trays, solvent agitator, and filters mounted in the tank of the washer. Parts are placed in the trays (baskets) and submerged below the cleaning solution level. This solution is agitated as air is forced through it. Some tanks are equipped with extra tank compartments for brushing, rinsing, and draining. Parts may be allowed to dry or blown dry.

g. Wire Brush and Scraper - Wire brushes and scrapers are used mainly to remove hard carbon deposits on piston heads, valves, grooves, corners, and combustion chambers. Dry cleaning is followed by washing the parts in a solvent and blowing dry. Power brushes are not recommended for cleaning soft parts.

h. Vapor Cleaning - Cleaning is accomplished by heating a nonflammable solution (Perchlorethylene) so that vapors settling on the parts from the solution will cause dirt to be released from the parts. The parts are suspended in metal baskets.

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5. Stone, Archie A., and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, New York, 1967

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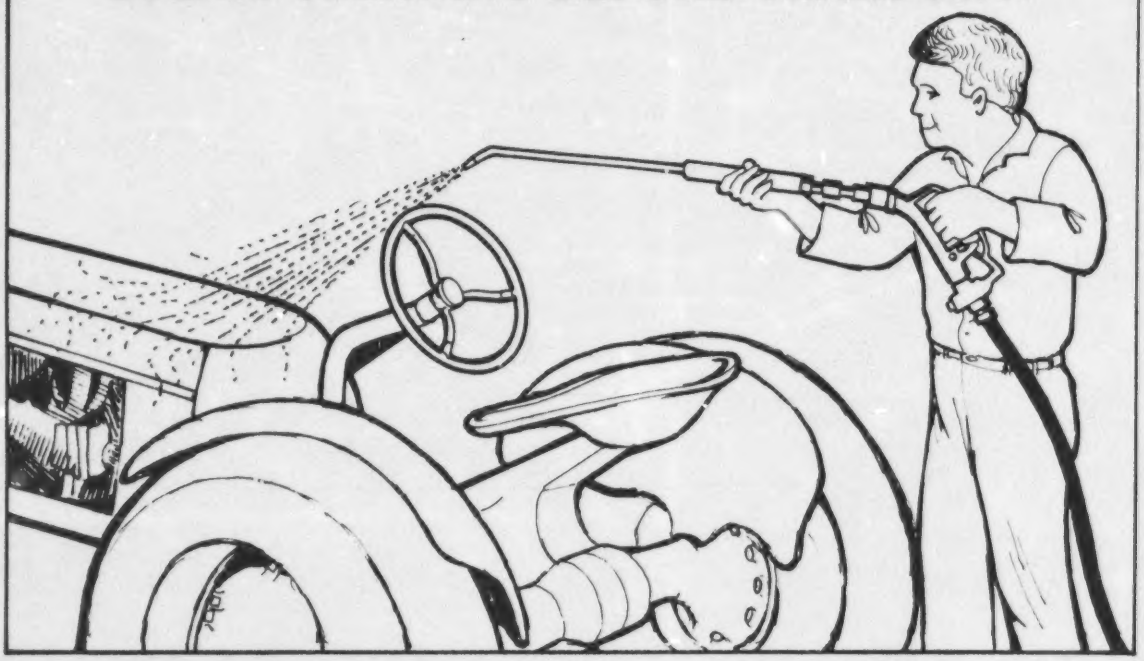
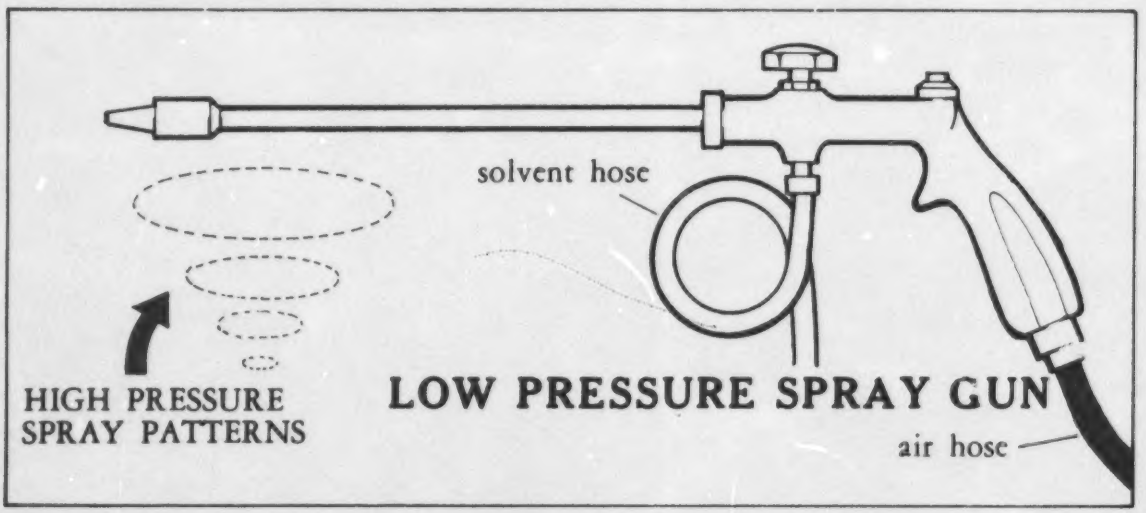
CLEANING METHODS

STEAM CLEANING BEFORE TEARDOWN

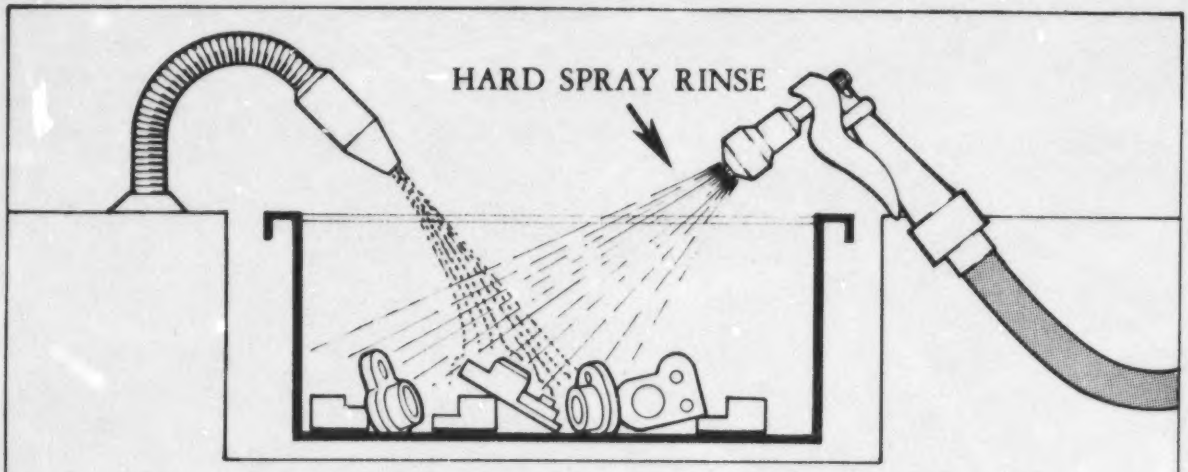




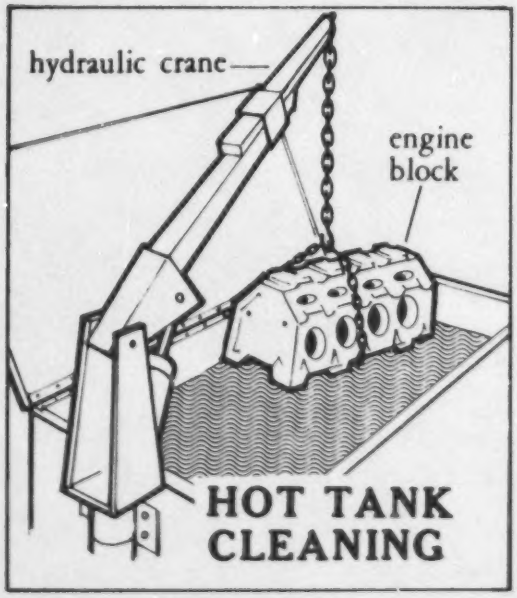
HIGH PRESSURE
SPRAY PATTERNS

LOW PRESSURE SPRAY GUN

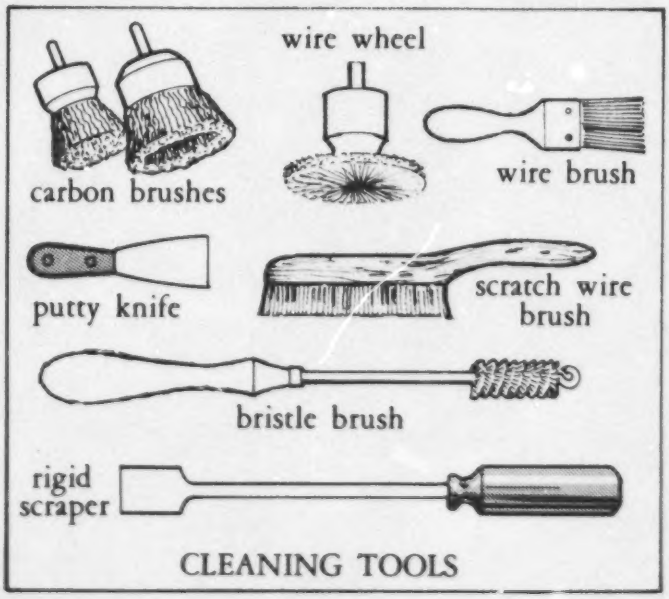
CLEANING METHODS



RINSING PARTS WITH FILTERED SOLVENT



HOT TANK CLEANING



CLEANING TOOLS

FENCE BUILDING AND REPAIR

Unit A: Planning, Building, and Maintaining Fences

Topic 1: Types of Fences, Fencing Materials, and Procedures

1. Introduction

Properly constructed, well-maintained fences are indispensable to a farm with crops and livestock, for they provide protection for crops and livestock. It would be impossible to establish many of the good management practices without good fencing.

In very early times exact property boundaries were of little importance, because there was an abundance of land and a small number of people. As the population increased, land became scarce; and the exact location of property boundaries became important. The first fences were constructed for the purpose of establishing property boundaries.

Stones were probably the first materials used for the construction of fences for agricultural purposes. Other fencing materials used about the same time were wood (split timbers), mud, and growing plants. Hedge rows are still used as fences in some European countries.

The first wire used as fencing material was smooth, made from flat iron, and coated with zinc. Its popularity was almost instant because it was relatively inexpensive, easy to use, and provided the needed protection for property, crops, and livestock. Barbs were added to the smooth wire to prevent livestock from scratching on it, to prevent it from becoming loose, and to prevent the animals from pushing through it.

Over 400 different designs of barb wire were produced by different inventors. Lucien B. Smith of Kent, Ohio, received the first patent on June 25, 1867. Many other patents followed.

The first woven wire was produced in 1883 by a Civil War veteran, who recognized the need for such a wire while burning split-rails to keep warm.

2. Kinds of Fences and Their Uses

The three categories into which fences may be grouped are permanent, temporary, and growing. The kind of fence to construct will depend upon the area

to be enclosed, purpose of fence, animals to be confined, and climatic conditions. Materials that may be used for constructing permanent fences are boards, woven wire, barb wire, or a combination of these. Permanent fences are constructed to enclose an area for an indefinite period of time.

Temporary fences are used to confine animals in an area for a short period of time, or to serve as temporary protection for plants, buildings, and equipment. They may be constructed of barb or woven wire, wooden panels, and electric wire.

Growing fences are formed by growing plants, such as hedges and some rose species. Growing fences may serve as a windbreak as well as a fence; however, they are not effective in the confinement of all types of livestock.

3. Tools Used in Constructing Fences

Certain tools must be available for the builder to properly construct a fence. Different tools are required to construct the various kinds of fences. Some of the larger tools needed are shown in the following transparency, and others are listed below:

Transparency No. 1

1. Stakes
2. Six-foot rule
3. Heavy cord
4. Tamping bar
5. Crowbar
6. Post driver
7. Chain and hand saws
8. Brace and assorted bits
9. Hammer
10. Axe
11. Wire splicer
12. Shovel
13. Leather gloves
14. Plumb bob
15. 16-foot pole
16. Chain saw

4. Fencing Materials

Transparency No. 2

Post - The three most commonly used posts for fences are wood, steel, and concrete. However, a fiberglass post is being marketed and is reported to have a long life expectancy. More wooden posts are used in the Southwest than any other kind, but the use of steel posts has increased in the last few years. Some ranchers are using both wooden and steel posts in fences.

The durability of wooden posts varies depending upon climatic conditions,

amount of heartwood, kind of wood used, whether the posts are treated or untreated, and the method of chemical treatment used. The most popular wooden posts in Texas are ashe juniper (cedar) and treated pine. Some farmers, however, still use split post oak posts.

Untreated cedar posts have a life expectancy of 15 to 25 years, and pressure treated pine posts have about the same length of life expectancy. Untreated pine posts are not recommended because of their short life expectancy, three to five years.

Two methods of treating pine posts are soaking and pressure treating. Posts soaked in a preservative will last from 15 to 20 years. Pressure treated posts have a longer life expectancy. Creosote, pentachlorophenol, and copper naphthenate are the preservatives most often used.

The three kinds of metal posts manufactured are the "A" bar, studded "Y", and the studded "T".

The studded "Y" and "T" posts are made of thicker metal; therefore, they have a longer life expectancy. One advantage of using metal posts is that they serve as a ground for the fence, thus provide protection from lightning. They are also fireproof.

Concrete posts are durable, but they are very heavy and are subject to breaking and weathering.

The type of soil, location of posts (wet soils, hillsides, and on the contour), and climatic conditions influence the size of wooden posts to use in the fence. General recommendations of diameter and length of wooden posts are as follows:

Kinds of Posts	Diameter	Length
Line	3-5"	6½-7 ft.
Corner and brace	4-6"	6½-7 ft.
Gate	6" or more	7½-8 ft.

Wire - Woven, barbed, and smooth are the three kinds of wire used for fencing. These are manufactured in the United States, as well as in several foreign countries. Wire manufactured in the U. S. is referred to as domestic wire, while wire manufactured in other countries is designated as imported.

A number of factors affect the life expectancy of wire. The most important is the amount or kind of protective coating on the wire. Rusting reduces the strength of the wire by reducing the wire size. Zinc (galvanized wire) and aluminum are the two coatings normally used. These coatings serve as a protective covering and delay the rusting of the wire. Zinc coating on wire

is measured in ounces per square foot of wire surface. The more zinc per square foot, the longer the wire will last before it starts rusting. The amount of zinc coating is designated by classes, which were established by the American Society for Testing. Wire with a Class I coating has the least amount of coating, while Class II has the greatest amount. Class III wire takes about twice as long as Class I before beginning to rust. During the handling of wire, care should be taken not to damage the zinc coating. Damaged wire rusts much faster. Aluminum coated wire has three to five times the corrosion resistance as does zinc coated wire, but it is much more expensive.

The hardness of steel used in the manufacture of wire affects its life expectancy. A medium-hard steel provides a springing action which is important to a long life expectancy.

Atmospheric temperature also affects wire. Wire expands during warm weather and contracts during cold weather. If the wire is stretched too tight in warm weather, it is a possibility that it will break in cold weather.

Transparency No. 3

Wire size is designated by its gauge. The smaller the gauge, the larger the diameter of the wire. Smaller gauge wires have less zinc coating; therefore, they start rusting much sooner.

Woven wire is used to confine small animals such as sheep, goats, and swine. It also is used to confine a combination of small animals and large animals. Woven wire is available in several different designs or styles. The words design and style are used interchangeably by the manufacturer. Wire designs are identified by numerals, such as 1155, 1047, 939, etc. The first two numerals in the design number denote the number of line wires (wires running lengthwise), and the last two numerals indicate the height of the wire in inches. For example, design 1155 has 11 line wires and is 55 inches high.

Wires vertical to the line wires are called stay wires. Some manufacturers include additional numerals along with the design numbers. The numerals may appear as 1155-12-11. As stated above, the first four digits are the style numbers. The next two digits, 12, are the number of inches of space between the stay wires; and the digits 11 designate the size of filler wire, the wires between the top and bottom line wires.

Woven wire has tension curves in the line wires to provide a springing action. Attention is directed to the above transparency, which shows the tension curves in woven wire that is properly stretched. The place where woven wire is joined is called a joint. Hinge and stiff-stay are the two kinds of joints used in the

manufacture of wire. The hinge joint is the most widely used.

Barb wire is available in gauge sizes of 12½, 13½, 14 and 15½. Two kinds of barbs are used in the manufacture of barb wire. These are two-point and four-point. Two-point barbs are usually spaced four inches apart, while the four-point barbs are spaced five inches apart. The barbs on some wire are wrapped around both strands. On others the barbs are wrapped around one strand. Barbs maintain their spacing better when wrapped around both strands. The amount of livestock pressure expected on the fence determines whether two-point or four-point should be used.

Smooth wire is used as a brace and to make the corner and brace posts rigid. It may also be used for constructing electric fences.

Transparency No. 4

Fence Fasteners - U-shaped and L-shaped staples are used to fasten wire fencing to wooden posts. The U-shaped staples are made from nine gauge wire and are 7/8 to 1 3/4 inches long. L-shaped staples may be purchased in lengths of 1½ to 2 inches. Both galvanized and ungalvanized staples are available.

The length of staple to use depends upon the hardness of the wooden posts. The recommended staple length for treated soft wood posts, such as pine, is 1½ to 2 inches. Based on recent research, the L-shaped staple has greater withdrawal resistance after the staple has been in the post for some time. The withdrawal resistance of the U-shaped staple decreases over the period of time it is in the post.

The proper method of using staples is shown in the above transparency. Although the L-shaped staple is not shown in the illustrations, they should be applied in the same manner as the U-shaped.

Galvanized wire fasteners are used to connect wires to steel posts. The fasteners are normally furnished by the dealer when the posts are purchased. There are several types of fasteners which are manufactured to be used on a particular post.

Galvanized steel wire is used to fasten the wires to concrete posts. A wire splicer can be used to twist the wire to the fence wire.

5. Laying Out the Fence Line and Right-of-Way

The information presented in this section applies to permanent fences, and it is assumed that the plans for the fences have been completed and their locations

have been determined. Seldom does a farmer have the opportunity of laying out all of the fences on a farm, but he may change some of the existing fences to meet the needs of his farming operation.

The first step in laying out a fence is to clear the right-of-way of obstructions, which may include trees, brush, rocks, and debris. It may be necessary to remove the old fence and posts. If these are not going to be used in the new fence, the old fence may be removed and buried with a bulldozer.

Transparency No. 5

If the wire and posts in the old fence are to be used in the new fence, the wire should be detached from the posts with fencing pliers or a wrecking bar.

Steel posts may be pulled out of the ground with the hydraulic lift on a tractor. The best method for pulling wooden posts out of the ground is to use an "A" - frame constructed of 2" x 6" lumber. A chain is secured to the post just above the ground level, is placed over the "A"-frame, and is secured to a tractor drawbar. As the tractor is driven forward, the post is pulled out of the ground.

Transparency No. 6

The procedure for laying out a fence line where the right-of-way is cleared and the terrain is level is explained below:

1. A stake about seven feet tall is set in the ground at each end of the fence line. The stake should be vertical with the ground level and driven into the ground deep enough for it to be steady. A white cloth is tied to the top of each stake.
2. Stakes are aligned at 100 feet intervals between the two end stakes. One person stands at one of the end stakes and aligns the interval stakes, which are carried by another person. A tall stake is used for sighting and aligning, but a much shorter stake is used to mark the 100 feet intervals.

The procedure for laying out fence lines in hilly or valley areas is as follows:

1. Long stakes with a white cloth attached to the tops are driven at the ends of the fence line (A and B).
2. Two stakes with white cloth tied to the tops are placed about 10 feet apart at the top of the hill, or at the lowest point in a valley.
3. The two center stakes are aligned from one of the end stakes.
4. The alignment of the center stakes is then checked from the other end stake. It may be necessary to move the center stakes several times before they are aligned. A person sighting at both end stakes will speed up the aligning process.

The following explanation gives the procedure for establishing a fence line in undergrowth:

Transparency No. 7

1. A pole 15 to 20 feet in length is set in the ground at the end of the fence line nearest to the underbrush. The pole should be long enough to be sighted from the other end of the fence and should be vertical to the ground.
2. A second stake is aligned with the end stakes as far into the underbrush as can be sighted.
3. Underbrush is cleared between the stakes that are in the underbrush.
4. If necessary other stakes are aligned in the underbrush before clearing more brush.

Transparency No. 8

The instructions given below are for constructing fences on the contour. The fence may be at the bottom of a terrace, along an irrigation canal, on the bank of a stream, or between strip crops.

1. The fence line is staked by placing stakes 16 feet apart.
2. Where the fence line makes a curve, three stakes are set.
3. A string line is drawn between the first and third stakes.
4. The distance between the string and center stake is measured. If the distance between the string and center stake is less than four inches, the posts may be spaced 16 feet apart. If the distance is more than four inches, the following spacing for posts should be used:

Distance from Center Stake to String Inches	Post Spacing Feet
4 to 5	15
5 to 6	14
6 to 8	12
8 to 14	10
14 to 20	8

The fence should make a uniform curve, as a uniform curve will cause the wire to have an equal amount of tension on each post.

Another method used to lay out a straight fence line is to place the corner posts at the ends of the fence line and tightly stretch a wire between the posts. The wire is used to align the stakes and is loosened and pulled aside to dig the post

holes. The wire may be used as one of the fence wires.

6. Constructing the Fence

The corner (anchor) and brace posts and the brace are the foundation of the fence and are important to the life expectancy of the fence.

Transparency No. 9

Holes for anchor or corner posts should be 3½ to 4 feet deep or deeper depending upon the type of soil and the method used to secure the posts. Posts set in concrete may be placed in shallower holes. If posts are set in concrete, the concrete should be allowed to dry before attaching the wire to the post or before placing stress on the posts by any means.

Posts should be placed in the center of the holes in order that the soil around them may be tamped uniformly. Each shovelful of soil added to the hole is tamped around the post. As the soil is being tamped around the post, the post should be checked periodically to make sure it is vertical with the ground.

If steel anchor posts and braces are used, they should be set in concrete. A large amount of concrete should be placed around the corner posts and braces.

After the corner post has been set, the brace post is set next. The distance between the anchor and brace post is measured with the brace and should be a minimum of eight feet. The longer the brace the more strength the anchor and brace assembly will have. The hole for the brace post is dug, and the brace post is placed in the hole, but is not tamped. The hole for the brace post should be a minimum of 3½ feet deep. If metal dowels are used to hold the brace in place, holes are drilled in both ends of the brace and in the two posts. If the brace is going to be placed in notches in the posts, the notches are measured and cut, and the brace is placed in the notches. Soil is placed around brace post and tamped.

The next step is to drive staples about four inches from the ground level in the anchor post and four inches above the brace on the brace post. Nine gauge smooth wire or barb wire is threaded through the staples, and two complete loops are made around the posts with the wire. The wire is pulled tight, and the loose ends are tied. A metal rod or stick is used to twist the wire until the wire becomes tight and the anchor and brace assembly is rigid.

Transparency No. 10

Different kinds of anchor and brace assemblies are shown in the above transparency. The type of assembly to use depends upon the length of the fence. If the fence is longer than 10 rods, the two-span end is recommended. Also, the two-span assembly is recommended for constructing line post brace assemblies.

Setting Line Posts - After holes have been dug, the line posts are aligned by sighting from one end, or by holding the posts against a wire that has been stretched between the two end posts. Depth of holes for the line posts is two to 2½ feet. The recommended spacing for line posts on different kinds of fences are as follows:

Barb wire - 12 to 14 feet
Woven wire - 15 to 16 feet
Board fence - 5 to 8 feet
Suspension fence - 50 to 80 feet

Steel posts may be driven into the ground with either a power or hand operated driver. The wire holding studs are turned to the fence side when the posts are driven in the ground.

Transparency Nos. 11a and 11b

Stretching Woven Wire - The roll of woven wire is placed with the close mesh end next to the post line.

1. The wire is rolled out to a length of about three line posts and is set on the close mesh end.
2. The first stay wire on the end is cut, loosened, and removed from the end of the line wires.
3. The bottom line wire is stapled into position. It should be about one inch above the ground if barb wire is not going to be placed under the woven wire. If barb wire is to be placed below the woven wire, the woven wire should be placed about three inches above the ground level.
4. The rest of the line wires are stapled into position from the bottom wire to the top.
5. Each line wire is pulled around the post and tied back to itself.
6. The rest of the roll of wire is unrolled to the next line post and brace assembly. It may be necessary to splice two of the rolls of woven wire together. This is accomplished by removing the stay wire to allow about four inches of line wire for the splice. The roll ends are pulled together until the stay wires meet, and the corresponding wires for each roll are tied to each other. Another method of splicing is to slip a metal sleeve over the wire ends and crimp the wires to the sleeve.

7. A dummy post is installed at the end of the fence line.
8. A clamp bar is attached to the fence, and a fence stretcher is attached to the bar and the dummy post.
9. The fence is tightened until about one-third of the tension curve has been removed from the wire. The exact amount of tension curve to remove will depend to some extent upon the weather.
10. The wire is attached to the anchor post with staples.
11. Enough stay wire is removed to allow the line wires to be pulled around the anchor post and to be tied back to themselves.
12. The middle line wire is cut and tied back to itself first. Then every other line wire is cut, pulled around the post and tied back to itself until all wires are cut and tied.

Stretching Barb Wire - Barb wire is fastened to the anchor post in the same manner as a line wire on a woven wire fence.

Barb wire is placed on the posts from the top wire down. This keeps the wires tight and prevents the other wire on the fence from becoming entangled as they are stretched.

The wire is unrolled down the side of the line post. To prevent kinks, the wire should be unrolled rather than looped off of the spool.

The wire is stretched with a fence stretcher at the opposite end of the fence. It is difficult to determine the amount of tension to place on barb wire, but it should not be so tight that it will break in cold weather.

After the barb wire has been stapled to the anchor post on the opposite end, one strand is cut, untwisted, pulled around the post, and tied back to itself. The other strand is then cut and tied back to itself and over the first strand.

The other wires are handled in the same manner. A jig made from a board and with nails driven in it at the proper wire spacings can be used to maintain the proper spacing between wires at each line post.

The number of wires used on a fence will determine the spacing of the wire. The following chart will assist one in determining the correct wire spacing.

Number of Wires	Fence	Distance Between Wires	Distance From Bottom Wire to Ground
3-Wire fence	48"	16"	16"
4-Wire fence	46"	10"	16"
5-Wire fence	52"	10"	12"
6-Wire fence	52"	8"	12"

Some barb wire fences are reinforced with twisted-wire or other types of stays. Twisted-wire stays are recommended for suspension fences.

Fencing Across Ditches, Gullies, and Streams-Wire is stretched across low places when the fence is being constructed, and later extra posts and wire or a structure, such as a water gate, are used to close the opening in the fence.

Transparency No. 12

Electric Fences - An electric fence is a temporary fence, which may be constructed of wooden or metal stakes and smooth or barb wire. The length of the electric fence will affect the decision whether to use an anchor and brace post assembly. Normally, the stakes are spaced 30 to 40 feet apart. The distance the wire is suspended from the ground is determined by the kind of livestock to be confined. For cattle and horses, the wire should be 2½ to 3 feet from the ground. Swine require that the wire be only ½ to 1½ feet from the ground. If two classes of animals, such as swine and cattle, are to be confined, a two-wire electric fence may be necessary.

To prevent the fence from becoming grounded, the wire is attached to insulators, which are attached to the posts or stakes. A screen door spring is often used to maintain tension on the electric wire(s) used for the gate. Also, an insulated handle is attached to the gate wire(s) to allow entry without being shocked. The gate wire(s) is usually spliced to a line wire by twisting a piece of line wire around the gate wire and in front of the gate wire insulator.

The electric fence controller should be Underwriter's Laboratory approved. The directions accompanying the controller should be read and followed.

Board Fences - If the fence is to be straight, a stake is driven at each corner, and a string is pulled tightly between the stakes. Post locations are located along the string at eight-foot intervals. The distance between the brace and corner posts may be less than eight feet; however, the distance should not be less than six feet. Holes for posts seven feet or longer should be dug a minimum of 2½ feet deep because of the force of the wind on the fence.

After the post holes have been dug and it has been determined that the posts can be aligned, the posts can be placed in the holes and the soil tamped around the posts. The vertical position of the posts should be checked as the soil is being tamped. If the builder wants all of the posts to be the same height without having to cut them off at the top, a string may be fastened to the tops of each of the corner posts and the hole depth adjusted to give the post the proper height. Some holes may have to be dug deeper, while soil may have

to be placed in the bottom of some holes. If soil is added to a hole, it should be tamped before placing the post permanently in the hole. It would probably be easier to saw the posts to the proper height after they have been tamped, particularly if a chain saw is available.

The board joints should be alternated on the fence. If the posts are located on centers at intervals of eight feet, this is a rather simple matter. The first board should be 16 feet long, and the next board under the first board should be eight feet long. Other boards are alternated in the same manner.

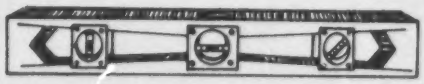
References:

1. "Building Fences", American Association for Vocational Instructional Materials, University of Georgia, Athens, Georgia, 1974

2. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

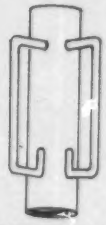
FENCING TOOLS

HAND DIGGER



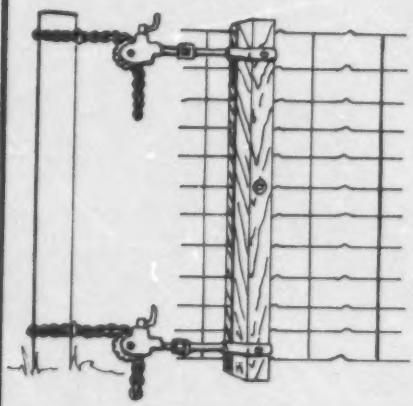
CARPENTER'S LEVEL

STEEL TAPE

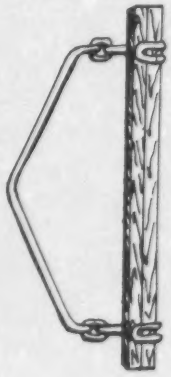


STEEL POST DRIVER

POWER DIGGER



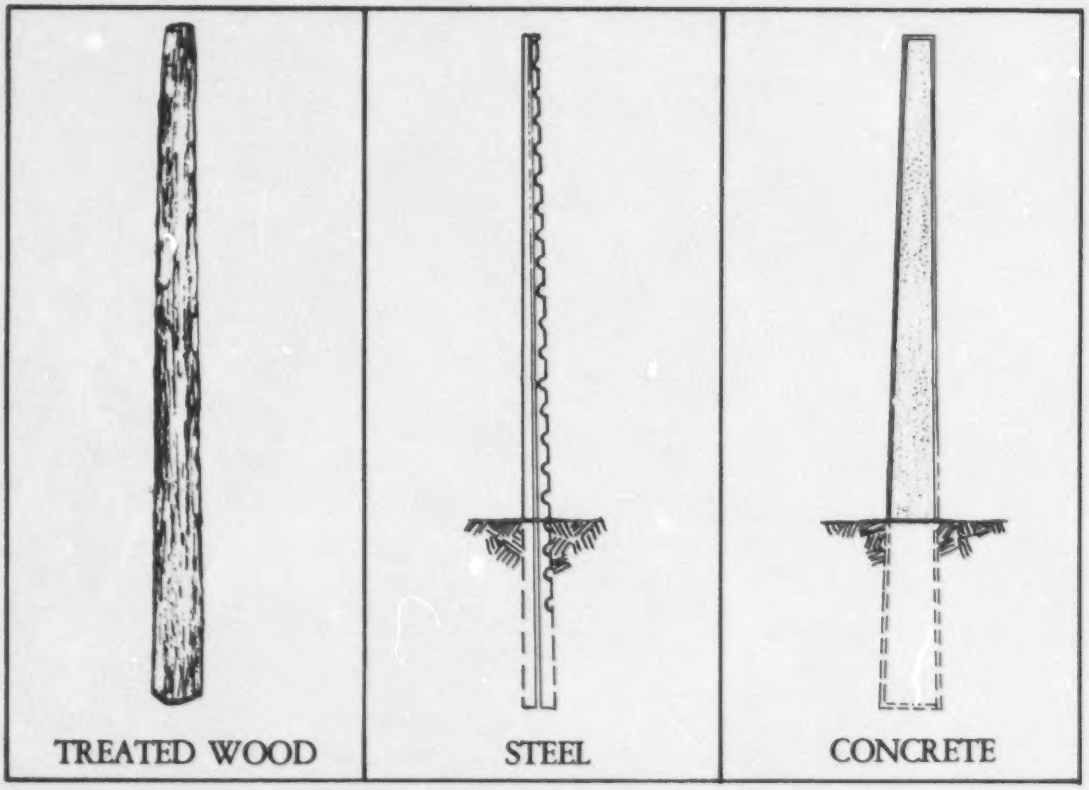
DOUBLE JACK STRETCHER



STRETCHING CLAMP

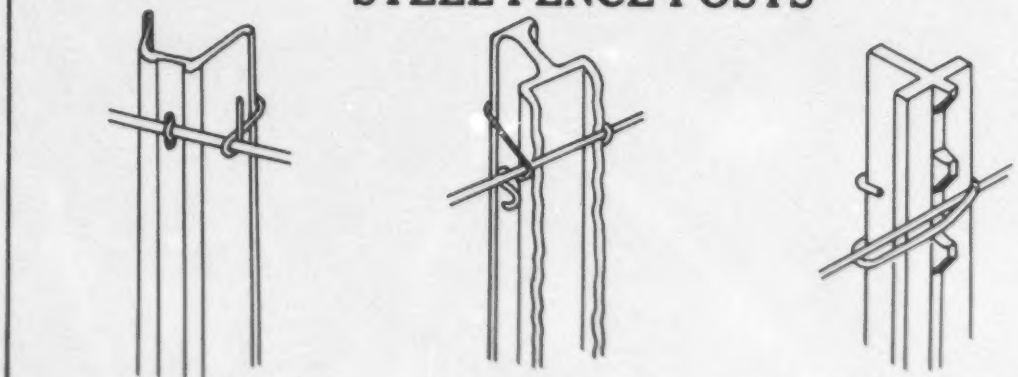
FENCING PLIERS

FENCE POSTS



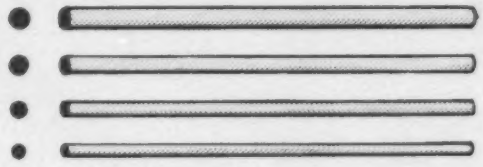
TREATED WOOD | STEEL | CONCRETE

STEEL FENCE POSTS



"U" BAR | STUDDED "Y" | STUDDED "T"

WIRE & WIRE GAUGES



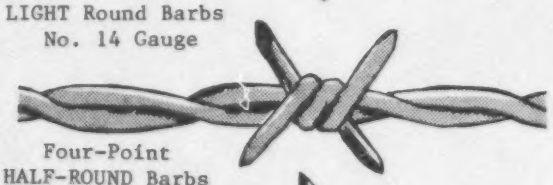
STEEL WIRE GAUGES

Two-Point
STANDARD Round Barb
No. 12½ Gauge

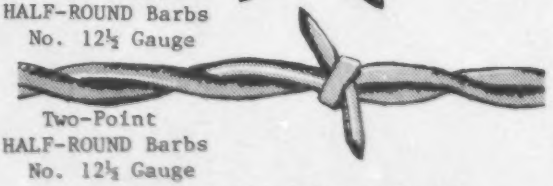
Four-Point
STANDARD Round Barb
No. 12½ Gauge

Two-Point
Flat Barbs
No. 12½ Gauge

Two-Point
LIGHT Round Barbs
No. 14 Gauge

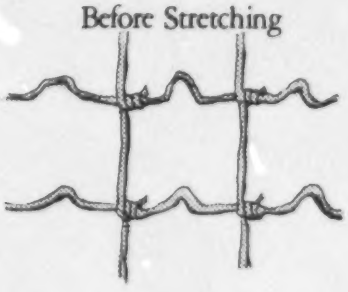


Four-Point
HALF-ROUND Barbs
No. 12½ Gauge

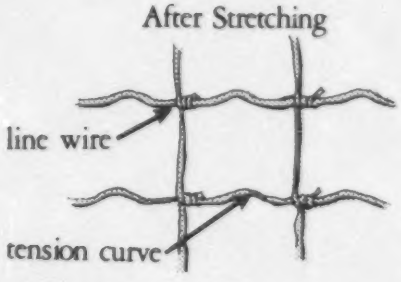


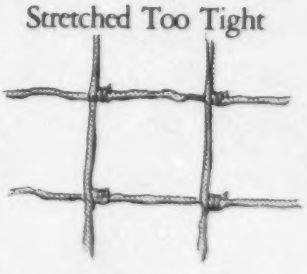
Two-Point
HALF-ROUND Barbs
No. 12½ Gauge

KINDS OF BARB WIRE



Before Stretching

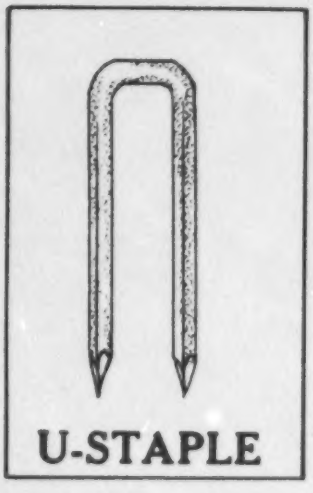




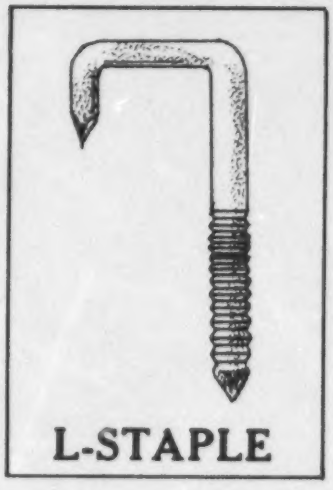
Stretched Too Tight

WOVEN WIRE

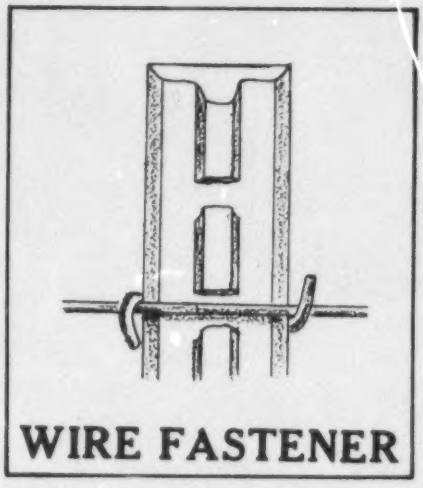
FASTENERS & THEIR USES



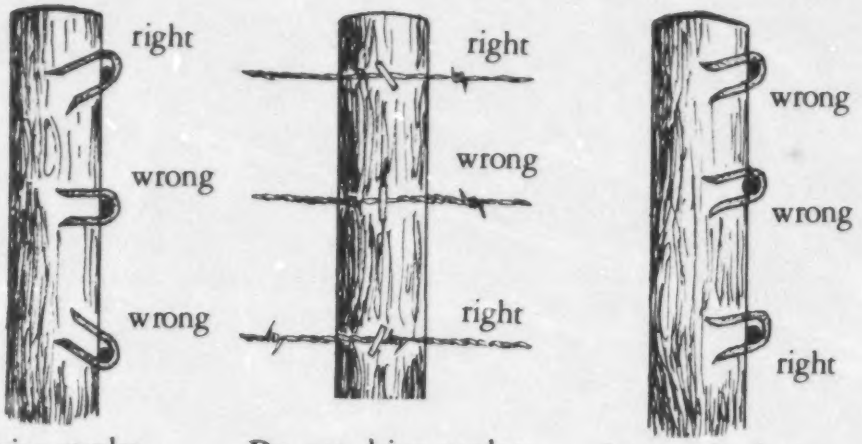
U-STAPLE



L-STAPLE



WIRE FASTENER



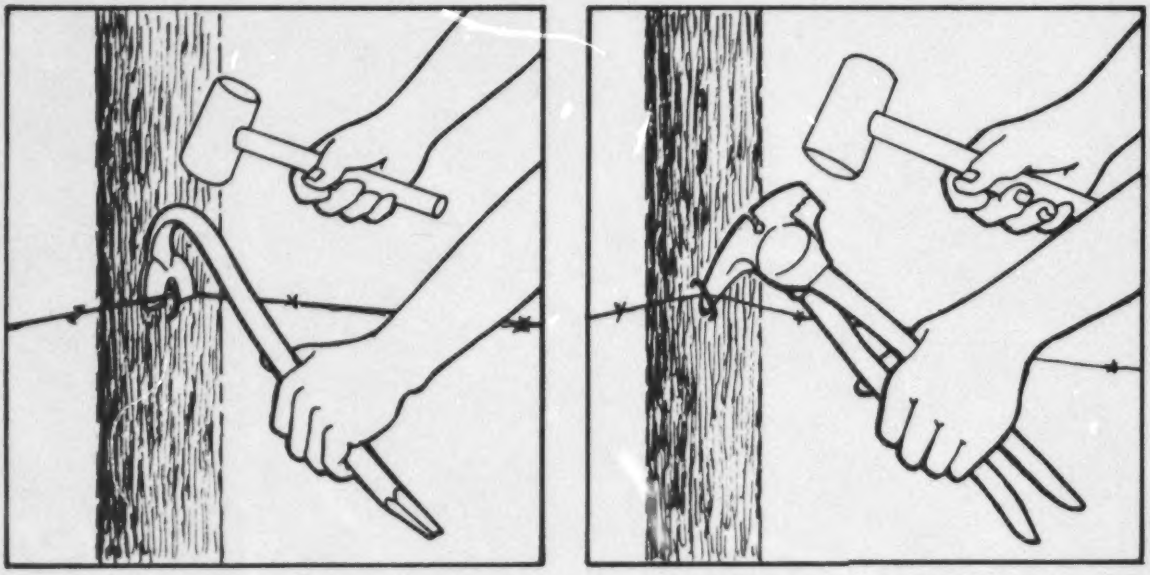
Drive staples at an angle

Do not drive staples parallel to side of post

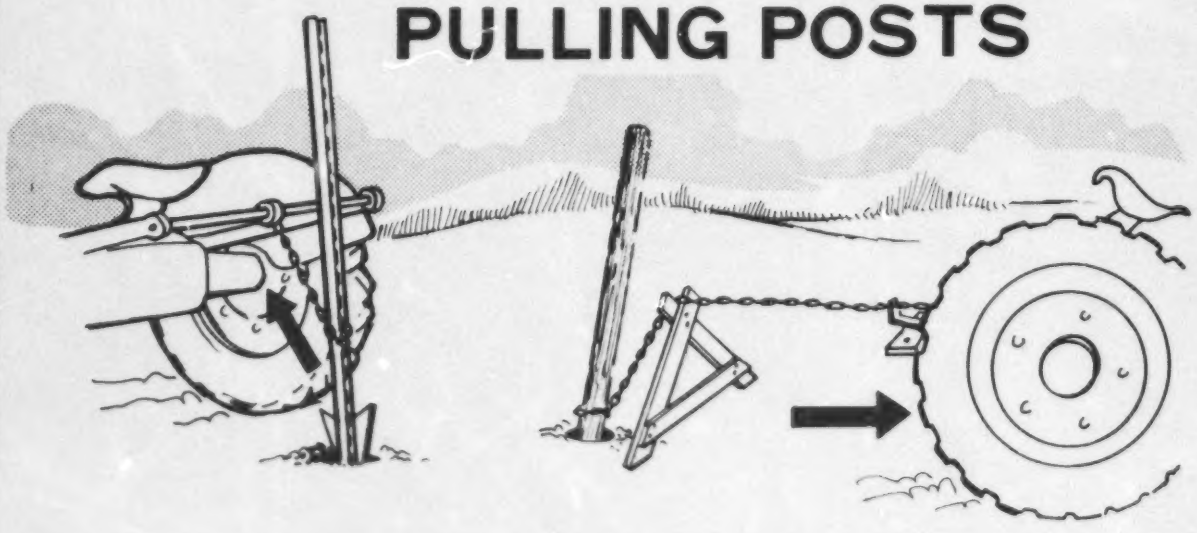
Leave wire loose in the staple

RIGHT & WRONG WAY TO USE STAPLES

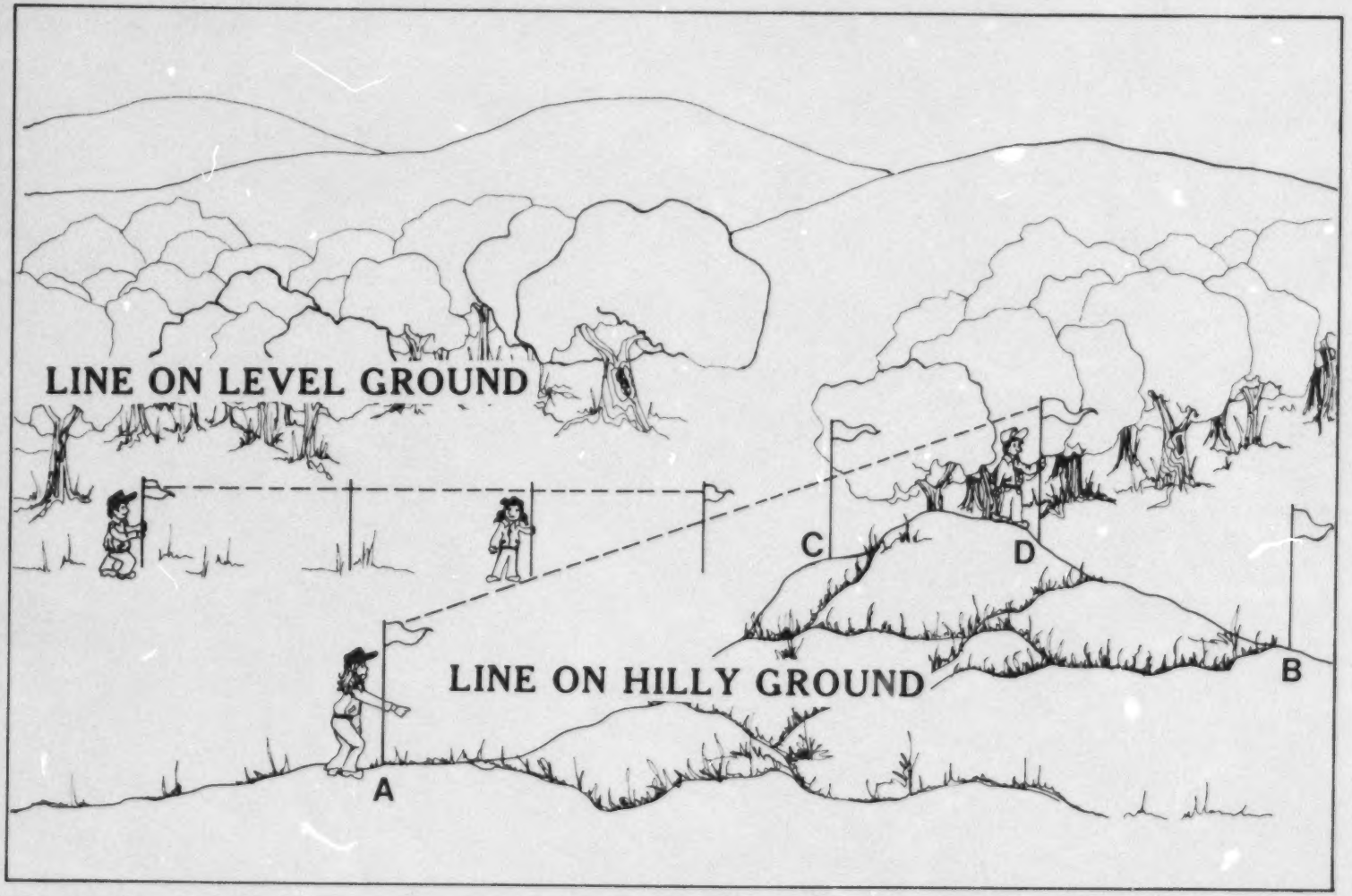
REMOVING WIRE



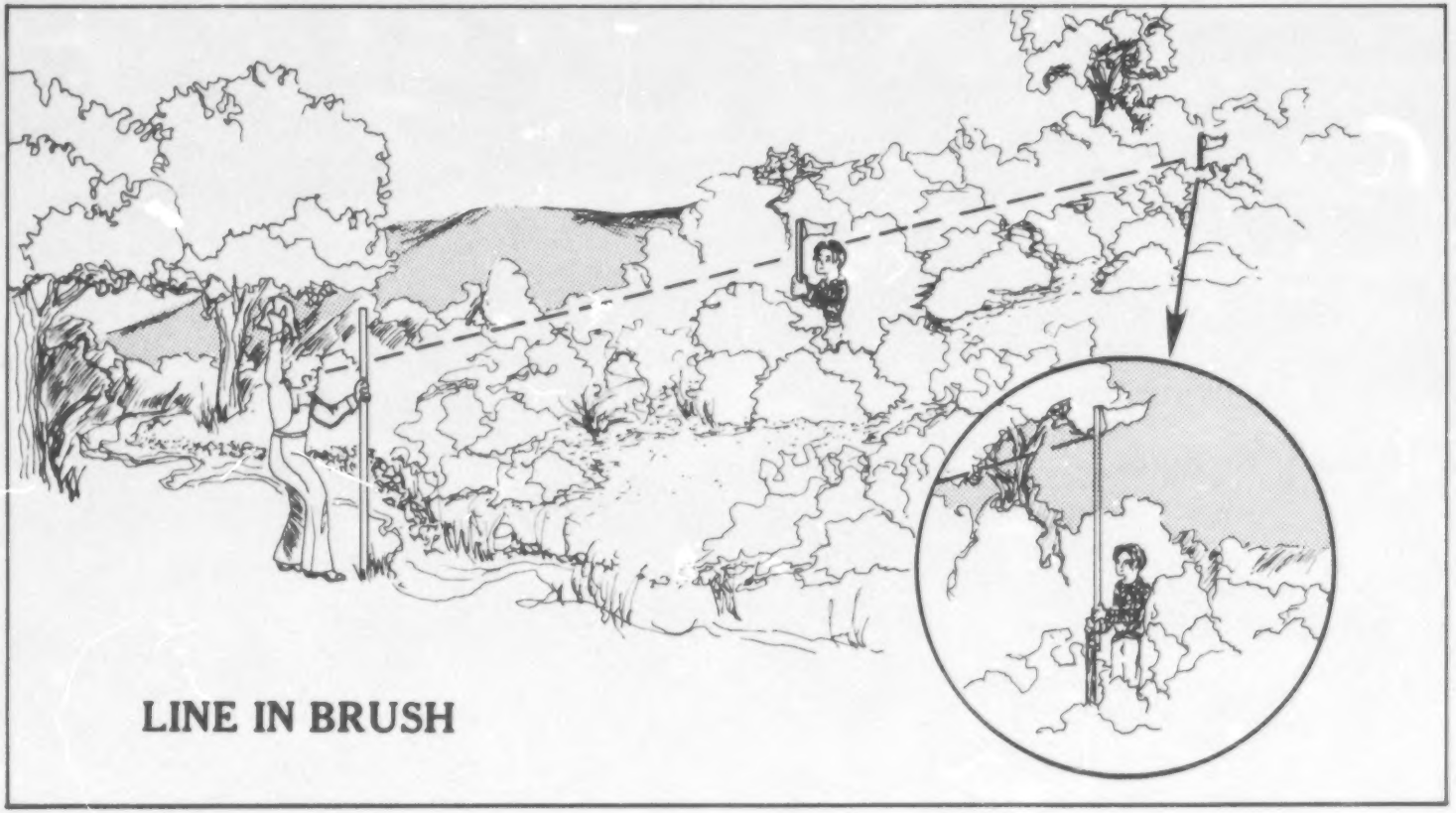
PULLING POSTS



DETERMINING FENCE LINE

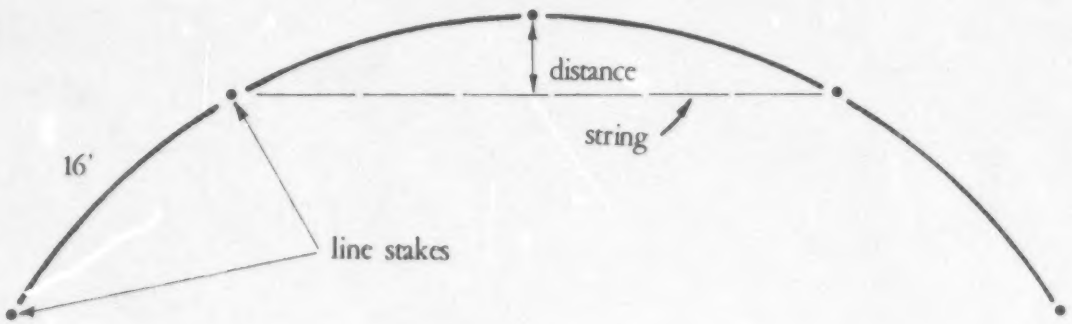


DETERMINING FENCE LINE

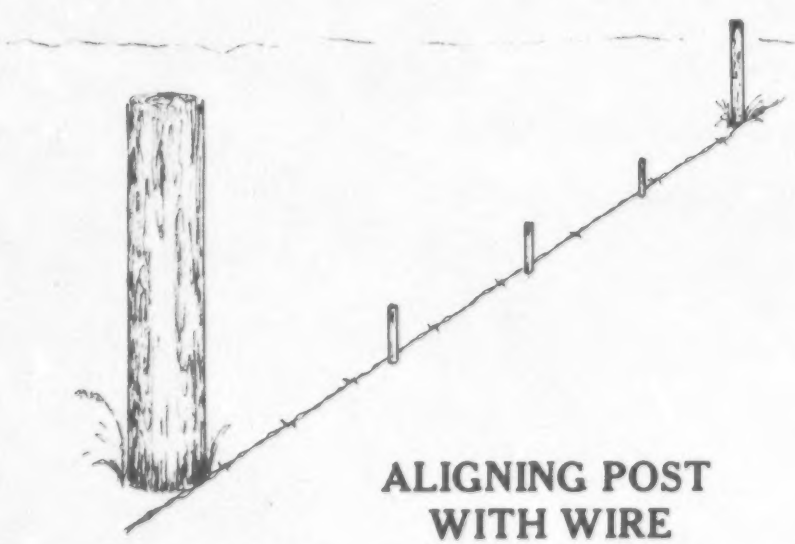


LINE IN BRUSH

DETERMINING FENCE LINE

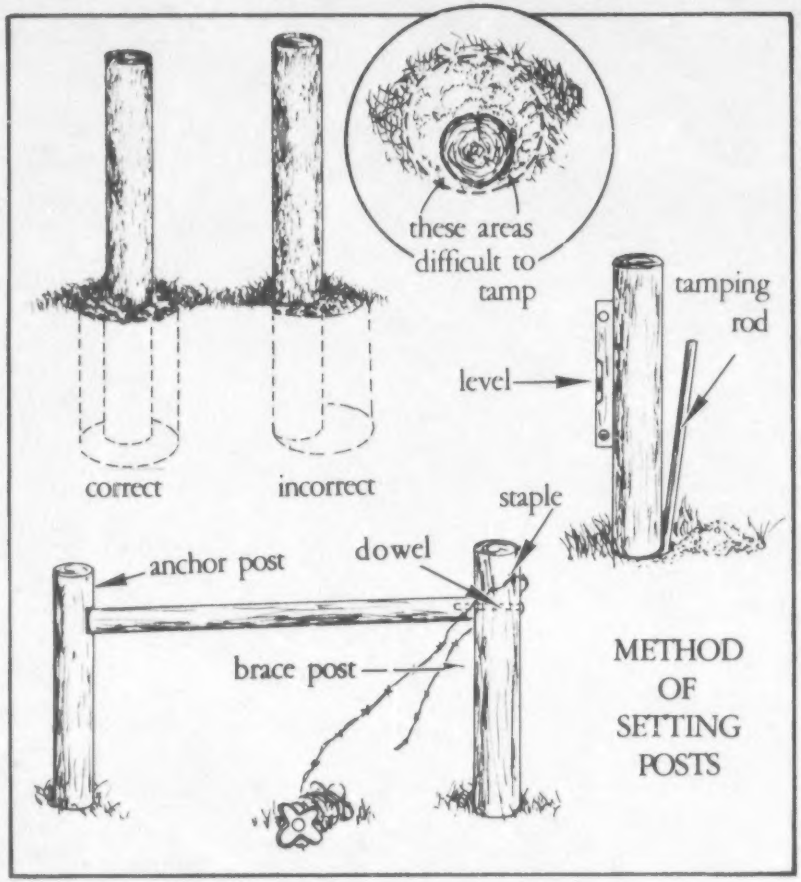


LINE ON CONTOUR

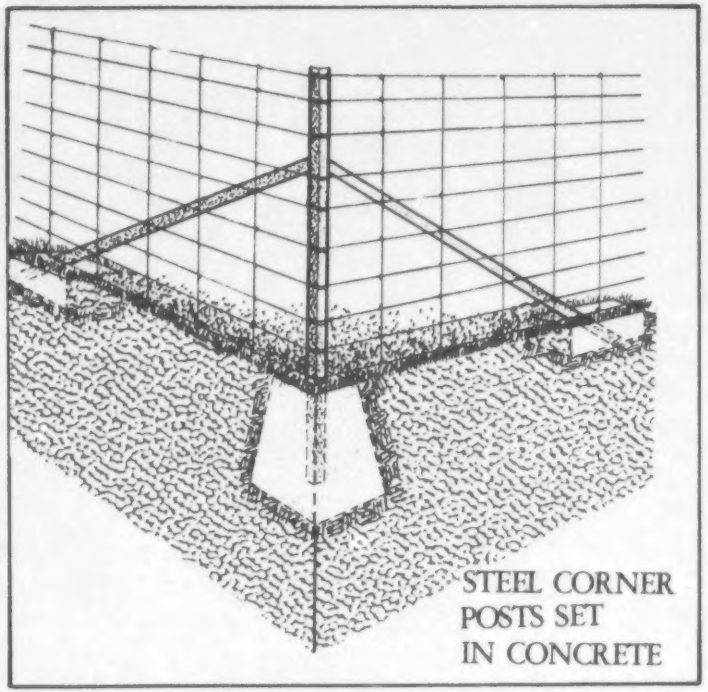


ALIGNING POST
WITH WIRE

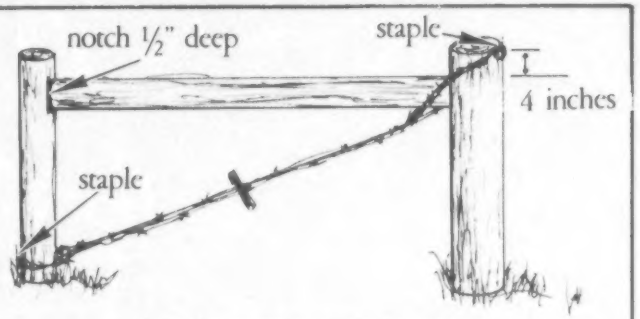
SETTING POSTS AND CONSTRUCTING ANCHOR ASSEMBLY



METHOD OF SETTING POSTS

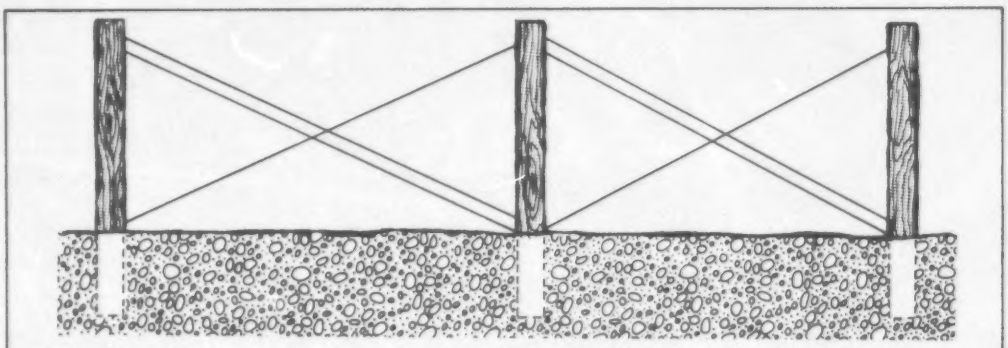


STEEL CORNER POSTS SET IN CONCRETE

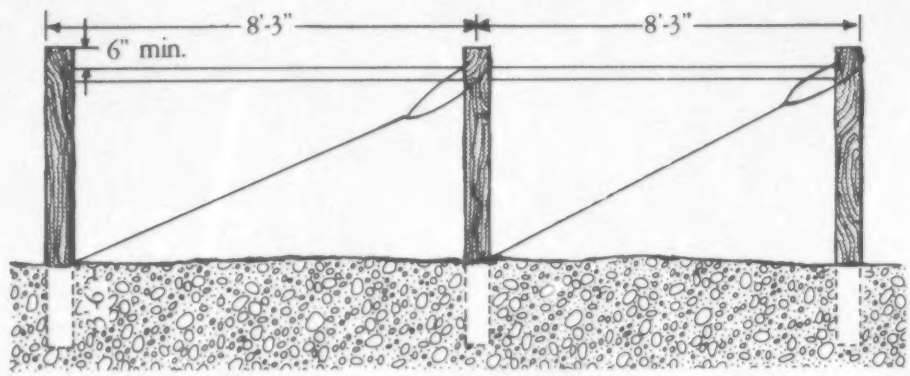


COMPLETED ASSEMBLY

ANCHOR ASSEMBLIES

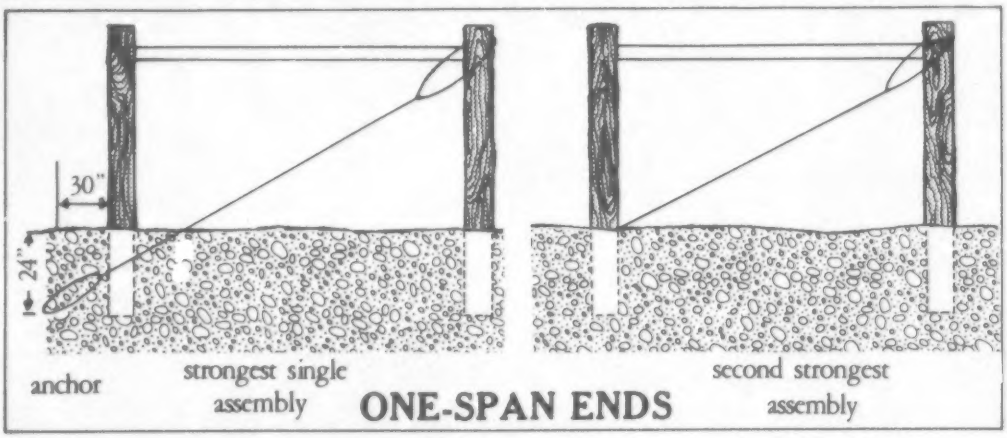


strongest assembly



second strongest assembly

TWO-SPAN ENDS



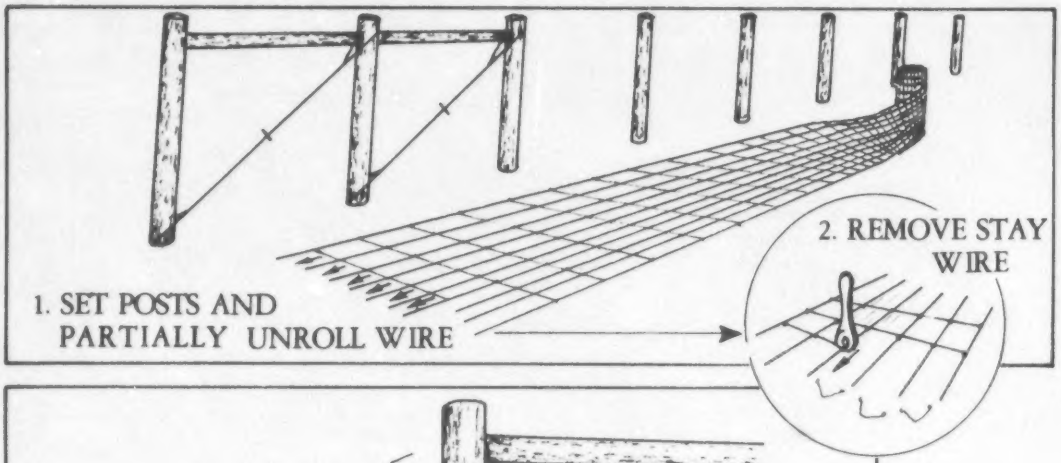
anchor

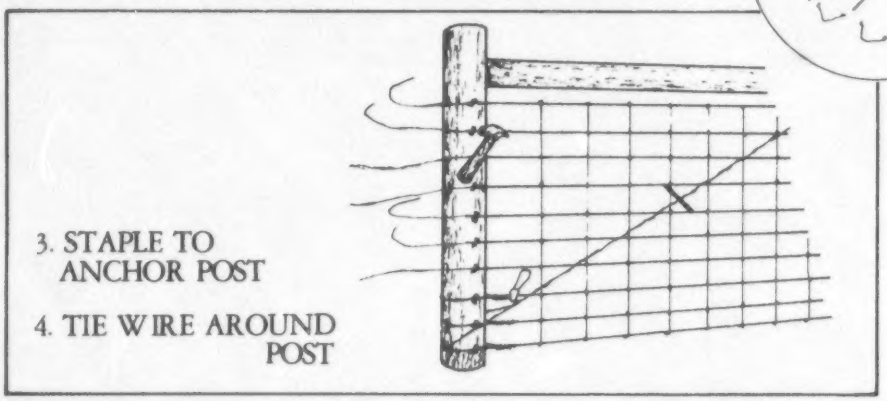
strongest single assembly

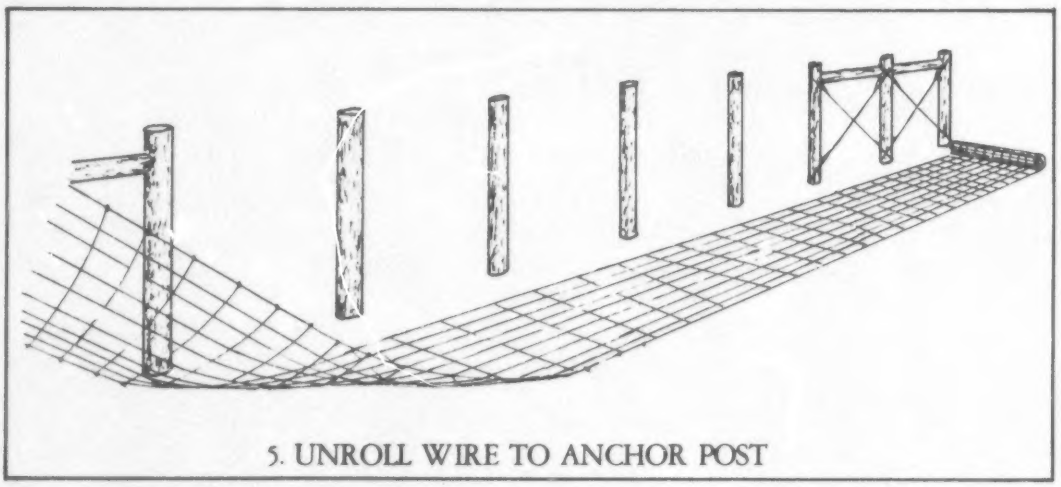
second strongest assembly

ONE-SPAN ENDS

STRETCHING WOVEN WIRE

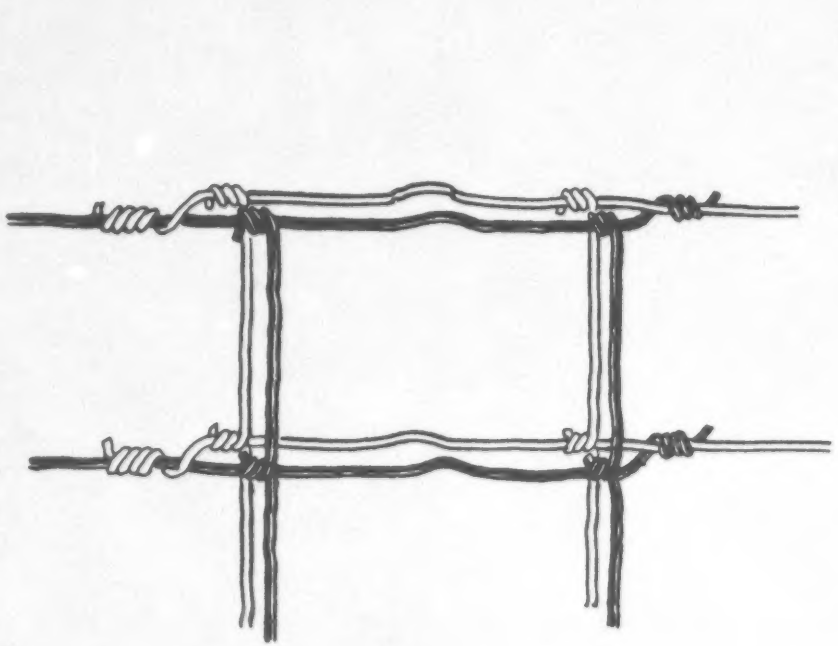




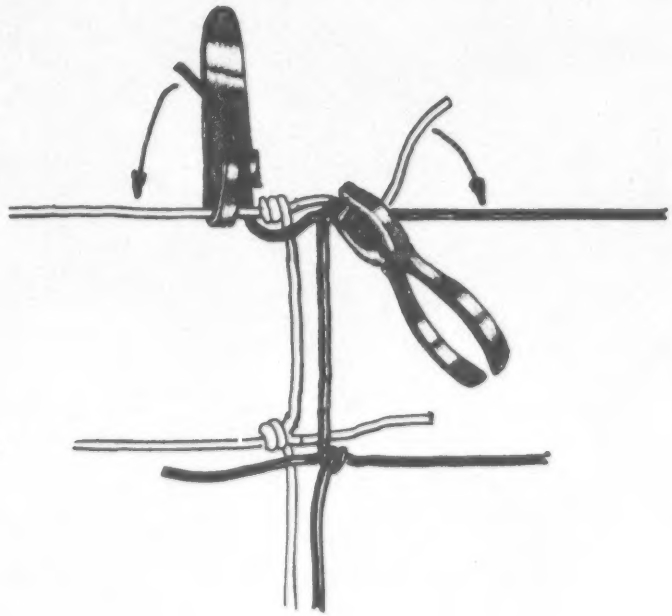


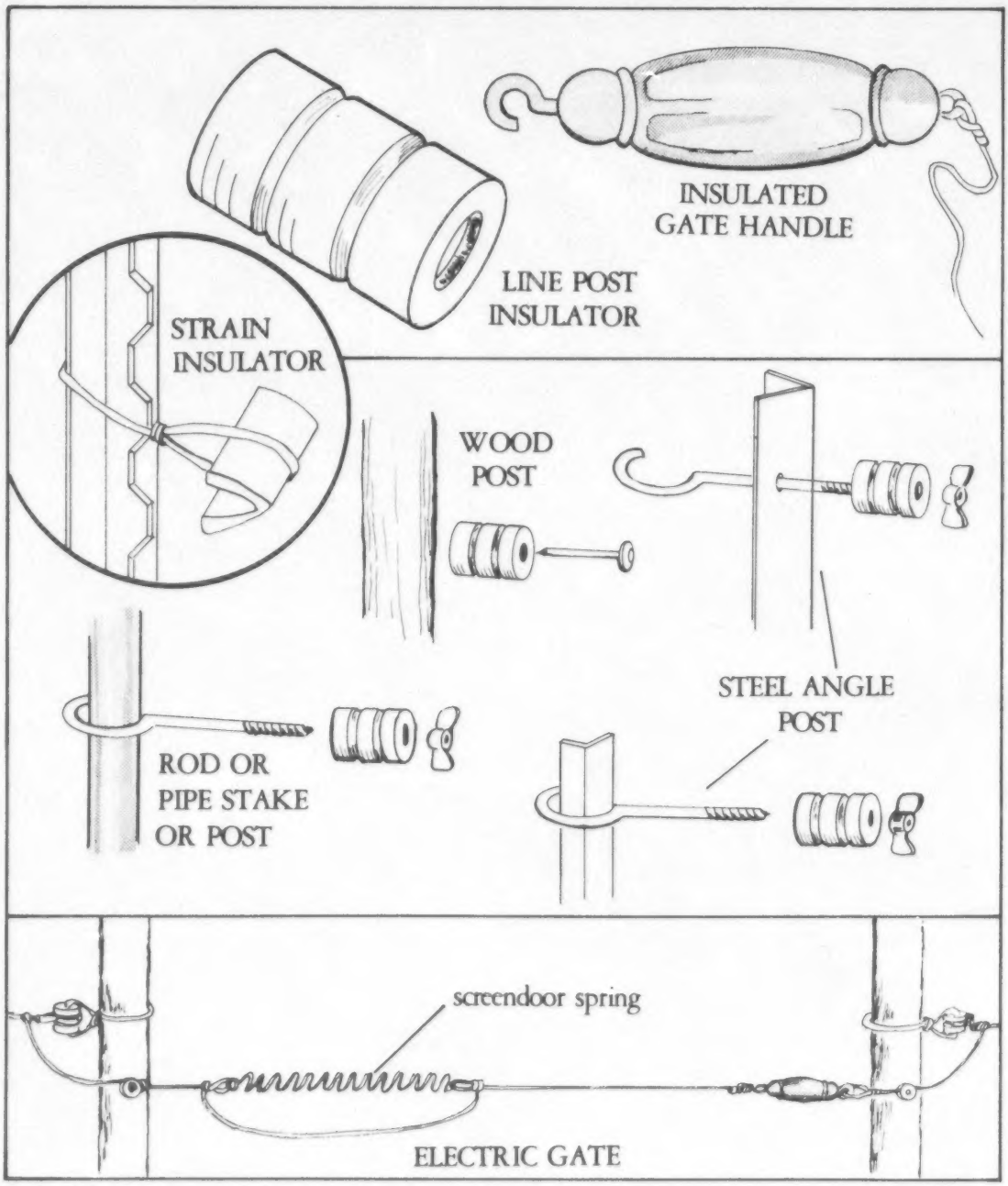
SPLICING WIRE

CORRECT WAY
TO SPLICE BARBED WIRE



MESH OVERLAP WOVEN WIRE



NO OVERLAP SPLICE

ELECTRIC FENCE EQUIPMENT